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Yamashita

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(54) **DATA TRANSMISSION METHOD AND APPARATUS**

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(52) **U.S. Cl.** **375/293**; 375/359; 375/363; 375/366; 370/513; 370/514; 348/473; 348/513; 348/521; 341/95; 341/102

(58) **Field of Search** 375/292, 293, 375/354, 359, 363, 365, 366, 368; 370/503, 506, 509, 512, 513, 514, 528; 348/500, 513, 521, 525, 526, 473, 474; 341/60, 95, 102, 103

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,486,739 A * 12/1984 Franaszek et al. 341/59
5,592,160 A * 1/1997 Bennett et al. 341/58
5,907,566 A * 5/1999 Benson et al. 714/798
6,054,944 A * 4/2000 Yamashita 341/58
6,225,924 B1 * 5/2001 Epshtein et al. 341/106
6,323,789 B1 * 11/2001 Lawrence 341/102

* cited by examiner

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(57) **ABSTRACT**

In transmitting ten-bit word string data including synchronous word data converted, at a transmitting side, from eight-bit word string data, representing signal information data synchronization required for reproducing the signal information is reliably established at a receiving side. An additional word data group containing eight-bit synchronous word data is inserted between words of the eight-bit word string data. Then, 8B–10B conversion is performed on the eight-bit word string data, thereby obtaining ten-bit word string data. In this case, the additional word data group is selected so that a running disparity of the ten-bit synchronous word data contained in the additional word data group of the composite ten-bit synchronous word data is consistently positive or negative.

22 Claims, 6 Drawing Sheets

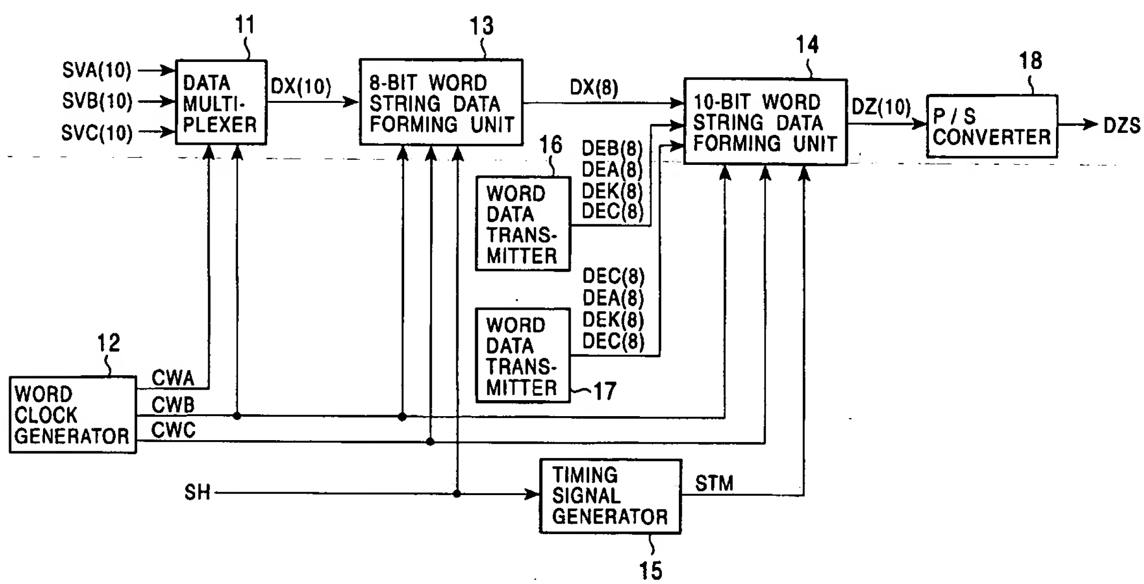


FIG. 1

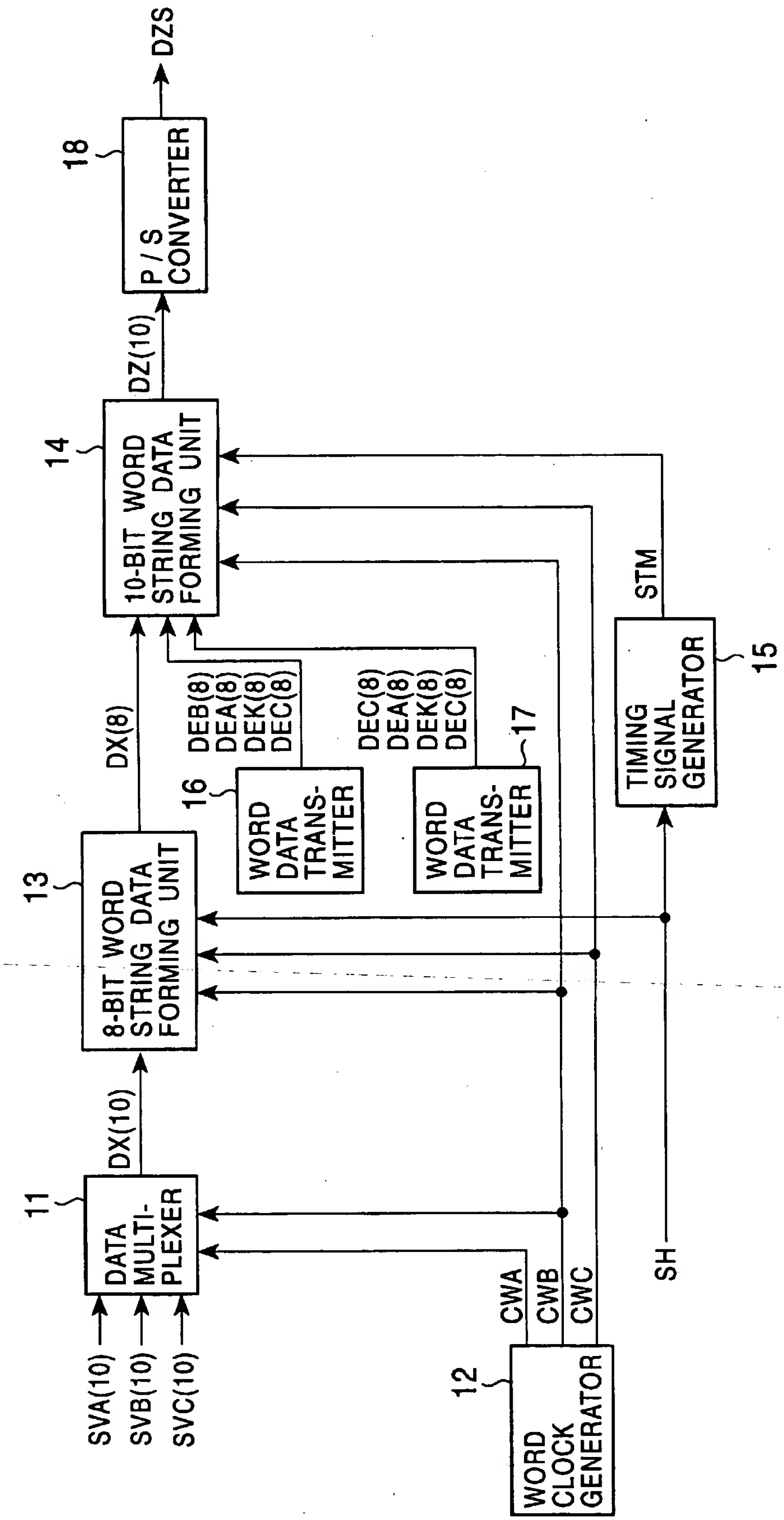

DZS
18
P / S CONVERTER
DZ(10)
14
10-BIT WORD STRING DATA FORMING UNIT
STM
15
TIMING SIGNAL GENERATOR
DX(8)
DEB(8) DEA(8) DEK(8) DEC(8)
DEC(8) DEA(8) DEK(8) DEC(8)
16
WORD DATA TRANS-MITTER
17
WORD DATA TRANS-MITTER
13
8-BIT WORD STRING DATA FORMING UNIT
DX(10)
11
DATA MULTI-PLEXER
SVA(10)
SVB(10)
SVC(10)
CWA
CWB
CWC
12
WORD CLOCK GENERATOR
SH

FIG. 2

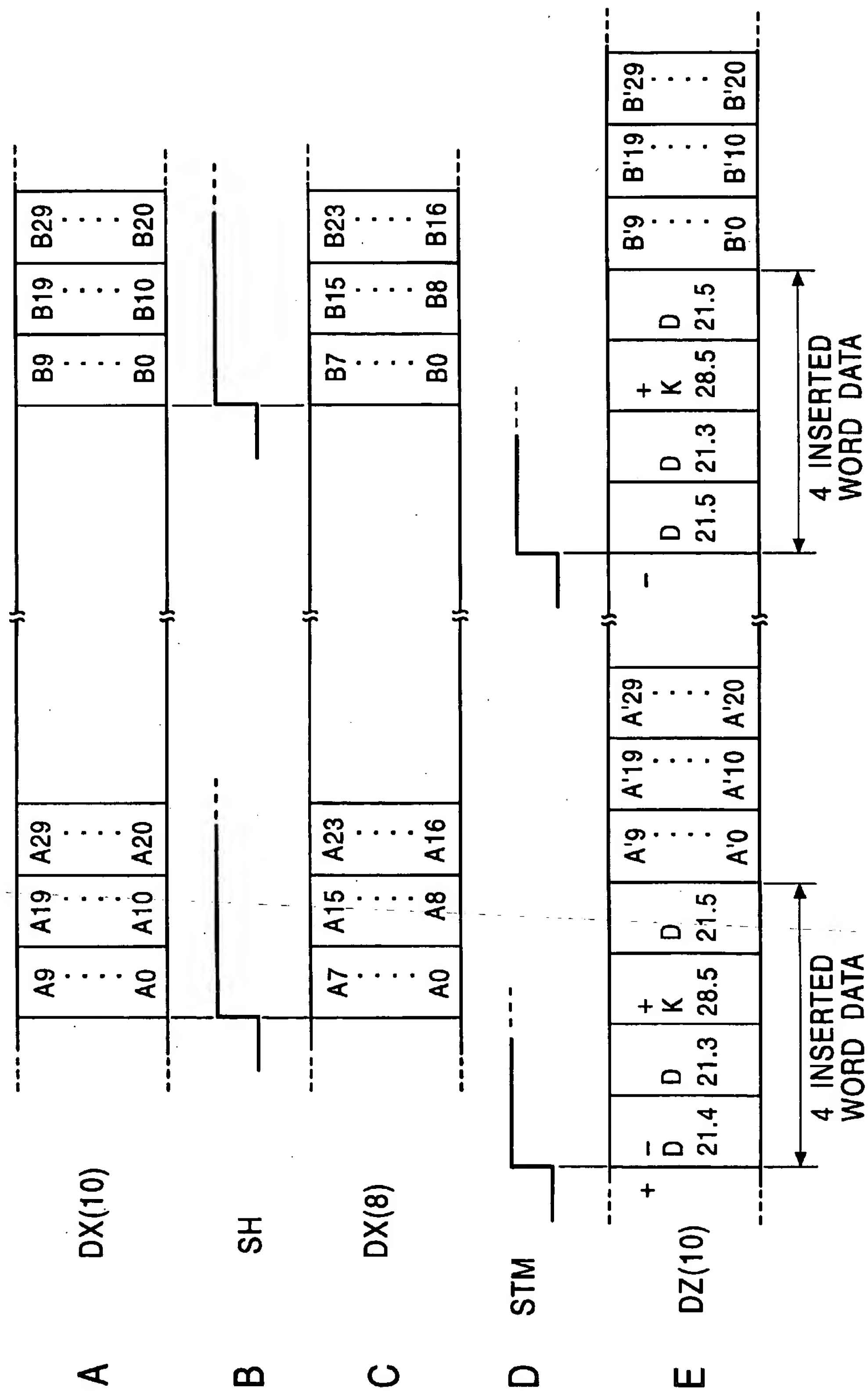
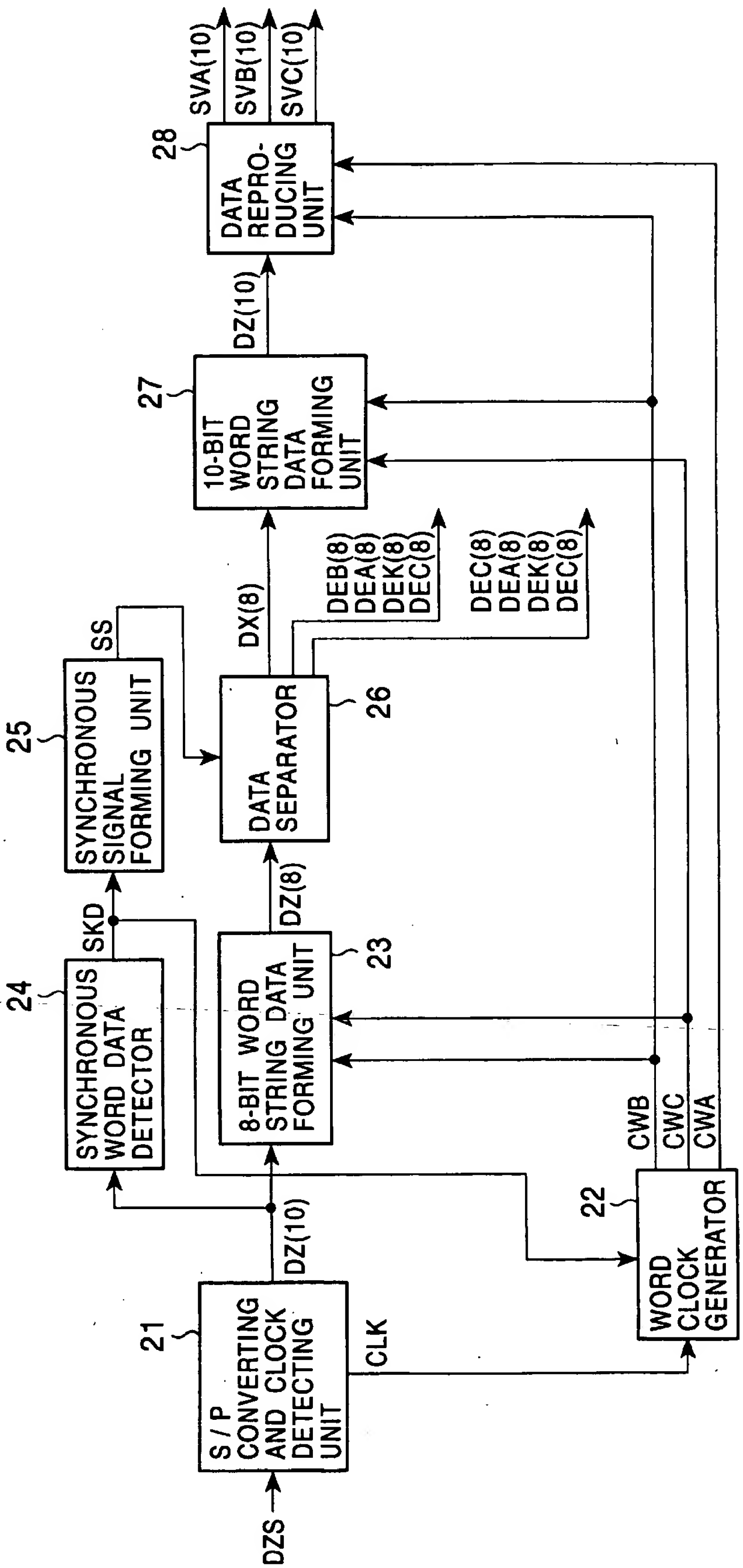

A DX(10)
A9 ..... A0
A19 ..... A10
A29 ..... A20
B9 ..... B0
B19 ..... B10
B29 ..... B20
B SH
C DX(8)
A7 ..... A0
A15 ..... A8
A23 ..... A16
B7 ..... B0
B15 ..... B8
B23 ..... B16
D STM
E DZ(10)
+
− D 21.4
D 21.3
+ K 28.5
D 21.5
A'9 ..... A'0
A'19 ..... A'10
A'29 ..... A'20
−
D 21.5
D 21.3
+ K 28.5
D 21.5
B'9 ..... B'0
B'19 ..... B'10
B'29 ..... B'20
4 INSERTED WORD DATA
4 INSERTED WORD DATA

FIG. 3

		CRD	–	+
DEA(8)	011 10101	D21.3	101010 1100	101010 0011
DEB(8)	100 10101	D21.4	101010 1101	101010 0010
DEC(8)	101 10101	D21.5	101010 1010	101010 1010

FIG. 4



DZS
21
S/P CONVERTING AND CLOCK DETECTING UNIT
DZ(10)
CLK
22
WORD CLOCK GENERATOR
CWB
CWC
CWA
24
SYNCHRONOUS WORD DATA DETECTOR
SKD
23
8-BIT WORD STRING DATA FORMING UNIT
DZ(8)
25
SYNCHRONOUS SIGNAL FORMING UNIT
SS
26
DATA SEPARATOR
DX(8)
DEB(8)
DEA(8)
DEK(8)
DEC(8)
DEC(8)
DEA(8)
DEK(8)
DEC(8)
27
10-BIT WORD STRING DATA FORMING UNIT
DZ(10)
28
DATA REPRO-DUCING UNIT
SVA(10)
SVB(10)
SVC(10)

FIG. 5

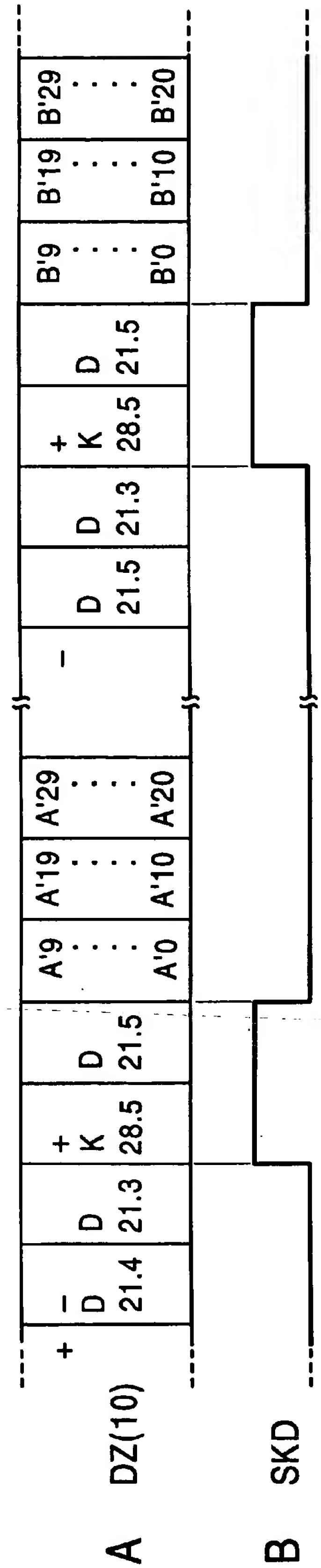

A
DZ(10)
B
SKD
+
–
D
21.4
D
21.3
+
K
28.5
D
21.5
A'9 . . . . A'0
A'19 . . . . A'10
A'29 . . . . A'20
–
D
21.5
D
21.3
+
K
28.5
D
21.5
B'9 . . . . B'0
B'19 . . . . B'10
B'29 . . . . B'20

FIG. 6

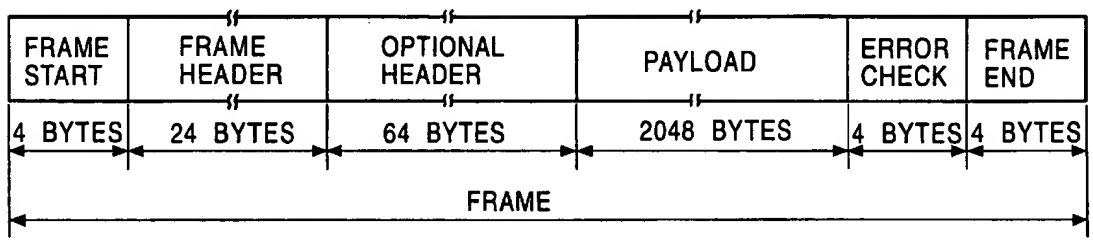


FIG. 7

CRD	−	+
DS(10)	001111 1010	110000 0101

DATA TRANSMISSION METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a data transmission method and apparatus for converting eight-bit word string data representing signal information, such as video signal information, converted from ten-bit word string data, into ten-bit word string data including synchronous word data, and for transmitting the converted data to a transmission channel.

2. Description of the Related Art

As one of the means for transmitting digital data indicating various signal information, such as video signal information, an optical transmission system is proposed in which digital data is converted into a light signal, and is transmitted through a transmission channel, which is formed of optical fiber. Digital data handled in this type of optical transmission system is converted into serial data having a bit rate of, for example, a few hundreds of Mbps to one Gbps.

Digital data handled in one of the optical transmission systems, e.g., in a fiber channel system, is converted in the following manner. At the transmitting side, eight-bit word string data (eight bits forms one word) is converted into ten-bit word string data (ten bits forms one word), i.e., 8B–10B conversion is performed. Further, parallel-to-serial conversion is performed on the resulting ten-bit word string data, thereby obtaining serial data. At the receiving side, serial-to-parallel conversion is performed on the received serial data. Then, the ten-bit word string data is converted into the original eight-bit word string data, i.e., 10B–8B conversion is conducted.

The digital data to be transmitted as the ten-bit word string data through the transmission channel, which is formed of an optical fiber, in the fiber channel system is compliant with the data format such as the one shown in FIG. **6**. In this data format, a packet is formed as the smallest unit, which is referred to as a "frame". The entire frame shown in FIG. **6** has 2148 bytes, and is formed of a 4-byte frame start field, a 24-byte frame header field, a 64-byte optional header field, a 2048-byte payload field, a 4-byte error check field, and a 4-byte frame end field. Among these frame fields, the 2048-byte payload field stores ten-bit word string data representing signal information. More specifically, at the transmitting side, a plurality of frames, each storing the ten-bit word data having a maximum amount of 2048 bytes in the payload field, are formed, and are sequentially transmitted. Upon receiving the frames, the receiving side extracts the ten-bit word string data from the payload fields of the individual frames.

In the above-described ten-bit word string data, the number of ones may be greater than the number of zeros, or the number of zeros may be greater than the number of ones, or the number of ones and the number of zeros may be equal. This can be represented by the concept of "running disparity (RD)". When the number of ones is greater than the number of zeros, RD is positive. When the number of zeros is larger than the number of ones, RD is negative. When the number of ones and the number of zeros are equal, RD is neutral. The word data having a greater number of ones than zeros is referred to as the "word data having a positive RD". The word data having a greater number of zeros than ones is referred to as the "word data having a negative RD". The word data having the same number of ones and zeros is referred to as the "word data having a neutral RD (neutral word data)".

In conducting 10B–8B conversion on the received ten-bit word string data, it is necessary for the receiving side to correctly identify the individual ten-bit word string data. Accordingly, at the transmitting side, synchronous word data is suitably inserted in the ten-bit word string data to be transmitted as serial data. Although the synchronous word data is also ten-bit word data, it has a specific code, which is not used for the regular ten-bit word data indicating information to be transmitted. If the RD of the word data positioned immediately before the synchronous word data to be inserted is negative, the RD of the synchronous word data is determined to be positive. Conversely, if the RD of the word data immediately before the synchronous word data to be inserted is positive, the RD of the synchronous word data is determined to be negative.

The synchronous word data may be ten-bit word data DS(**10**), whose code name is referred to as "K28.5". FIG. **7** illustrates such ten-bit word data DS(**10**). When the CRD, which is the RD of the previous word data, is negative (–), the word data DS(**10**) results in "001111 1010" having a positive RD. In contrast, when the CRD, which is the RD of the previous word data, is positive, the word data DS(**10**) results in "110000 0101" having a negative RD (hereinafter "001111 1010" is referred to as "+K28.5", while "110000 0101" is referred to as "K28.5").

It is now assumed that the ten-bit word string data to be transmitted designates video signal information. To enhance the transmission efficiency, it is desired that the greatest possible number of ten-bit word string data be stored in the payload field of each frame. Thus, at the transmitting side, ten-bit word string data corresponding to many horizontal periods of the video signal are stored in the payload field of each frame. Meanwhile, to establish horizontal synchronization in performing data processing by the receiving side, it is desired that synchronous word data be inserted in the ten-bit word string data corresponding to every horizontal period of the video signal.

To fulfil the above-mentioned function of the synchronous data, it is now assumed that the synchronous data is inserted as **+K28.5** or **–K28.5** according to whether the RD of the previous word data is negative or positive, as stated above.

As discussed above, at the transmitting side of, for example, the fiber channel system, many frames are formed in which ten-bit word string data, added with the word data DS(**10**) as the synchronous word data, are stored in the payload fields. The frames are then sequentially transmitted. Upon receiving the frames, the receiving side extracts the ten-bit word string data from the payload field of each frame and detects the synchronous word data, generally, as follows, before processing the ten-bit word string data. Only the word data DS(**10**) having a positive RD, i.e., **+K28.5**, is detected as the synchronous data. Alternatively, only the word data DS(**10**) having a negative RD, i.e., **–K28.5**, is detected as the synchronous data. This is because a predetermined restriction is imposed on the addition of the synchronous word data to the ten-bit word string data. Due to this restriction, it is sufficient for the receiving side to detect only **+K28.5** or **–K28.5** of the synchronous word data.

However, if only the word data DS(**10**) having a positive RD, i.e., **+K28.5**, or only the word data DS(**10**) having a negative RD, i.e., **–K28.5**, is detected, the following problem is caused when the receiving side performs data processing under the following situation. That is, to fulfil the function of the synchronous word data, as stated above, the word data DS(**10**) having a positive RD, i.e., **+K28.5**, or the word data DS(**10**) having a negative RD, i.e., **–K28.5**, is

inserted in the ten-bit word string data corresponding to every horizontal period of the video signal according to whether the RD of the previous word data is negative or positive.

More specifically, if only +K28.5 or −K28.5 is detected as synchronous data at the receiving side, the synchronous word data cannot be detected for the ten-bit word string data corresponding to every horizontal period of the video signal in processing the ten-bit word string data. As a result, in reproducing the video signal information represented by the ten-bit word string data, correct horizontal synchronization may not be reliably established.

Consequently, in transmitting digital data representing various signal information, such as video signal information, accompanied by the 8B–10B conversion and the addition of the synchronous word data at the transmitting side, and the detection of the synchronous word data and the 10B–8B conversion at the receiving side, the use of integrated circuit (IC) devices for processing digital data in, for example, the fiber channel system, becomes difficult. By using the above types of IC devices, the word data DS(10) having a positive RD, i.e., +K28.5, or the word data DS(10) having a negative RD, i.e., −K28.5, is inserted as the synchronous word data in the ten-bit word string data corresponding to every horizontal period of a signal according to whether the RD of the previous word data is negative or positive. Thus, the above-described problems occur in detecting the synchronous word data from the ten-bit word string data at the receiving side.

SUMMARY OF THE INVENTION

Accordingly, in view of the above background, it is an object of the present invention to provide a data transmission method and apparatus in which, after transmitting ten-bit word string data including synchronous word data, converted from eight-bit word string data representing signal information, such as video signal information, data synchronization, which is required for reproducing the signal information, such as converting the ten-bit word string data into the eight-bit word string data, is reliably established at the receiving side even if only the synchronous word data having a positive RD or only the synchronous word data having a negative RD is detected at the receiving side.

In order to achieve the above object, according to one aspect of the present invention, there is provided a data transmission method including: a receiving step of receiving eight-bit word string data indicating signal information; an insertion step of inserting an additional word data group including specific synchronous word data and at least one item of auxiliary word data, each data having eight bits and a predetermined code, between words of the eight-bit word string data in accordance with a predetermined timing signal; a conversion step of converting the eight-bit word string data provided with the additional word data group into ten-bit word string data; a forming step of forming composite ten-bit word string data including the additional word data group containing ten-bit synchronous word data which is converted from the specific synchronous word data; and a transmission step of transmitting the composite ten-bit word string data. In the above-described insertion step, the additional word data group is selected so that the RD of the ten-bit synchronous word data contained in the additional word data group of the composite ten-bit synchronous word data is consistently positive or negative.

According to another aspect of the present invention, there is provided a data transmission apparatus including a digital data forming unit for forming eight-bit word string data indicating signal information. A ten-bit word string data forming unit inserts an additional word data group including specific synchronous word data and at least one item of auxiliary word data, each data having eight bits and a predetermined code, between words of the eight-bit word string data in accordance with a predetermined timing signal, and converts the eight-bit word string data provided with the additional word data group into ten-bit word string data, thereby forming composite ten-bit word string data including the additional word data group containing ten-bit synchronous word data which is converted from the specific synchronous word data. A data transmitting unit transmits the composite ten-bit word string data. The ten-bit word string data forming unit inserts the additional word data group between the words of the eight-bit word string data so that the RD of the ten-bit synchronous word data contained in the additional word data group of the composite ten-bit synchronous word data is consistently positive or negative.

According to the aforementioned data transmission method and data transmission apparatus, as discussed above, the composite ten-bit word string data to be transmitted includes ten-bit synchronous word data constantly having a positive or negative RD. Such ten-bit synchronous word data is set to be the word data DS(10) having a positive RD, i.e., +K28.5, or the word data DS(10) having a negative RD, i.e., −K28.5. It is determined whether the ten-bit synchronous word data contained in the composite ten-bit word string data constantly exhibits positive or negative according to which RD, i.e., positive or negative, of the synchronous word data the receiving side detects.

The composite ten-bit word string data transmitted as described above can be correctly and suitably detected as synchronous word data required for converting from the ten-bit word string data into the eight-bit word string data by the receiving side. It is thus possible to reliably establish data synchronization required for reproducing signal information represented by the received composite ten-bit word string data by the receiving side.

According to the aforementioned data transmission method and data transmission apparatus, integrated circuit (IC) devices provided for digital data processing in, for example, a fiber channel system, can be effectively utilized.

The additional word data group contained in the composite ten-bit word string data may be formed of four, three, or two word data.

It is now assumed that the additional word data group contained in the composite ten-bit word string data has four word data. When the RD of ten-bit word data positioned immediately before the additional word data group is positive, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a negative RD, ten-bit word data having a neutral RD, ten-bit synchronous word data having a positive RD, and another ten-bit word data, or may include the ten-bit word data having a negative RD, the ten-bit synchronous word data having a positive RD, and another ten-bit word data. Conversely, when the RD of ten-bit word data positioned immediately before the additional word data group is negative, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a neutral RD, another ten-bit word data having a neutral RD, the ten-bit synchronous word data having a positive RD, and another ten-bit word data, or may include the ten-bit word data having a neutral RD, the ten-bit synchronous word data having a positive RD, and another ten-bit word data.

Alternatively, when the RD of ten-bit word data positioned immediately before the additional word data group is negative, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a positive RD, ten-bit word data having a neutral RD, ten-bit synchronous word data having a negative RD, and another ten-bit word data, or may include the ten-bit word data having a positive RD, the ten-bit synchronous word data having a negative RD, and another ten-bit word data. Conversely, when the RD of ten-bit word data positioned immediately before the additional word data group is positive, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a neutral RD, another ten-bit word data having a neutral RD, the ten-bit synchronous word data having a negative RD, and another ten-bit word data, or may include the ten-bit word data having a neutral RD, the ten-bit synchronous word data having a negative RD, and another ten-bit word data.

It is now assumed that the additional word data group contained in the composite ten-bit word string data is formed of three word data. When the RD of ten-bit word data positioned immediately before the additional word data group is positive, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a negative RD, ten-bit word data having a neutral RD, and ten-bit synchronous word data having a positive RD, or may include the ten-bit word data having a negative RD and the ten-bit synchronous word data having a positive RD. Conversely, when the RD of ten-bit word data positioned immediately before the additional word data group is negative, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a neutral RD, another ten-bit word data having a neutral RD, and the ten-bit synchronous word data having a positive RD, or may include the ten-bit word data having a neutral RD and the ten-bit synchronous word data having a positive RD.

Alternatively, when the RD of ten-bit word data positioned immediately before the additional word data group is negative, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a positive RD, ten-bit word data having a neutral RD, and ten-bit synchronous word data having a negative RD, or may include the ten-bit word data having a positive RD and the ten-bit synchronous word data having a negative RD. Conversely, when the RD of ten-bit word data positioned immediately before the additional word data group is positive, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a neutral RD, another ten-bit word data having a neutral RD, and the ten-bit synchronous word data having a negative RD, or may include the ten-bit word data having a neutral RD and the ten-bit synchronous word data having a negative RD.

It is now assumed that the additional word data group contained in the composite ten-bit word string data is formed of two word data. When the RD of ten-bit word data positioned immediately before the additional word data group is positive, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a negative RD and ten-bit synchronous word data having a positive RD. Conversely, when the RD of ten-bit word data positioned immediately before the additional word data group is negative, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a neutral RD and the ten-bit synchronous word data having a positive RD.

Alternatively, when the RD of ten-bit word data positioned immediately before the additional word data group is negative, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a positive RD and ten-bit synchronous word data having a negative RD. Conversely, when the RD of ten-bit word data positioned immediately before the additional word data group is positive, the additional word data group of the composite ten-bit word string data may include ten-bit word data having a neutral RD and the ten-bit synchronous word data having a negative RD.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating a data transmission apparatus which employs a data transmission method according to an embodiment of the present invention;

FIG. **2** is a timing chart illustrating an operation performed by the data transmission apparatus shown in FIG. **1**;

FIG. **3** illustrates the concept of auxiliary word data used in the data transmission apparatus shown in FIG. **1**;

FIG. **4** is a block diagram illustrating a data receiving apparatus for receiving data transmitted from the data transmission apparatus shown in FIG. **1**;

FIG. **5** is a timing chart illustrating an operation performed by the data receiving apparatus shown in FIG. **4**;

FIG. **6** illustrates the concept of a "frame" used in transmitting digital data; and

FIG. **7** illustrates the concept of synchronous word data used in transmitting digital data.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is described below in detail through illustration of a preferred embodiment.

Referring to the block diagram of a data transmission apparatus according to an embodiment of the present invention shown in FIG. **1**, ten-bit word string data SVA(10), SVB(10), and SVC(10), representing three types of video signal information, are supplied to a data multiplexer **11**. Word clock signals CWA and CWB are supplied from a word clock generator **12** to the data multiplexer **11**. The ten-bit word string data SVA(10), SVB(10), and SVC(10) are multiplexed in the data multiplexer **11** based on the word clock signals CWA and CWB while synchronizing the horizontal periods of the individual data with each other, thereby forming multiplexed ten-bit word string data DX(10). The multiplexed ten-bit word string data DX(10) is configured, as indicated by A of FIG. **2**, such that the individual horizontal periods are formed of corresponding ten-bit word data (**A0** through **A9**), (**A10** through **A19**), (**A20** through **A29**), and so on, and corresponding ten-bit word data (**B0** through **B9**), (**B10** through **B19**), (**B20** through **B29**), and so on. In each horizontal period of the multiplexed data DX(10), the horizontal periods of the corresponding three types of video signal information SVA (10), SVB(10), and SVC(10) are multiplexed and stored.

The multiplexed ten-bit word string data DX(10) is supplied from the data multiplexer **11** to an eight-bit word string data forming unit **13**. Supplied to the eight-bit word string data forming unit **13** are not only word clock signals CWB and CWC transmitted from the word clock generator **12**, but also a common horizontal synchronous signal SH, which is used for all the video signal information SVA(10), SVB(10), and SVC(10). In the eight-bit word string data forming unit **13**, 10B–8B conversion is performed on the multiplexed

ten-bit word string data DX(10), based on the word clock signals CWB and CWC, by using the leading edge of the horizontal synchronous signal SH as a reference point, as indicated by B of FIG. 2, thereby forming multiplexed eight-bit word string data DX(8) converted from the multiplexed ten-bit word string data DX(10).

The multiplexed eight-bit word string data DX(8) is configured, as shown by C of FIG. 2, such that the individual horizontal periods are formed of corresponding eight-bit word data (A0 through A7), (A8 through A15), (A16 through A23), and so on, and corresponding eight-bit word data (B0 through B7), (B8 through B15), (B16 through B23), and so on. In each horizontal period of the multiplexed data DX(8), the horizontal periods of the corresponding three types of video signal information SVA(10), SVB(10), and SVC(10) are multiplexed and stored.

The multiplexed eight-bit word string data DX(8) is supplied from the eight-bit word string data forming unit 13 to a ten-bit word string data forming unit 14. Not only the word clock signals CWB and CWC transmitted from the word clock generator 12, but also, a timing signal STM based on the horizontal synchronous signal SH transmitted from a timing generator 15, are supplied to the ten-bit word string data forming unit 14. Also supplied to the ten-bit word string data forming unit 14 are a first additional word data group including four eight-bit word data, such as auxiliary word data DEB(8), auxiliary word data DEA(8), synchronous word data DEK(8), and auxiliary word data DEC(8), from a word data transmitter 16 and a second additional word data group including four eight-bit word data, such as auxiliary word data DEC(8), auxiliary word data DEA(8), synchronous word data DEK(8), and auxiliary word data DEC(8), from a word data transmitter 17.

In the ten-bit word string data forming unit 14, the first additional word data group transmitted from the word data transmitter 16 or the second additional word data group from the word data transmitter 17 is inserted between words of the multiplexed eight-bit word string data DX(8) according to the timing signal STM. Then, 8B–10B conversion is conducted, based on the word clock signal CWC and CWB, on the multiplexed eight-bit word string data DX(8) provided with the first additional word data group or the second additional word data group. As a result, composite ten-bit word string data DZ(10) based on the eight-bit word string data DX(8) provided with the first additional word data group or the second additional word data group is formed.

With this arrangement, the synchronous word data DEK (8), which is originally eight-bit word data, becomes the above-described word data DZ(10) when being converted into ten-bit word data. Accordingly, the synchronous word data DEK(8) is referred to by a code name, i.e., K28.5, when being converted into ten-bit word data. If the CRD, which is the RD of the word data positioned immediately before the synchronous word data DS(10), is negative (–), the synchronous word data DEK(8) becomes +K28.5. Conversely, if the CRD of the previous word data is positive (+), the synchronous word data DEK(8) becomes –K28.5.

The auxiliary word data DEA(8), DEB(8), and DEC(8) are eight-bit word data, as shown in FIG. 3, indicated by "011 10101", "100 10101", and "101 10101", respectively. When being converted into ten-bit word data, the auxiliary word data DEA(8), DEB(8), and DEC(8) are referred to by code names, such as D21.3, D21.4, and D21.5, respectively. If the CRD of the previous word data is negative (–), the RD of D21.3 is set to be neutral, i.e., "101010 1100". If the CRD of the previous word data is positive (+), the RD of D21.3 is set to be neutral, i.e., "101010 0011". Concerning D21.4, if the CRD of the previous word data is negative (–), the RD of D21.4 is set to be positive, i.e., "101010 1101" (hereinafter referred to as "+D21.4"). If the CRD of the previous word data is positive (+), the RD of D21.4 is set to be negative, i.e., "101010 0010" (hereinafter referred to as "–D21.4"). The RD of D21.5 is always neutral "101010 1010" regardless of whether the CRD of the previous word data is negative or positive.

In the ten-bit word string data forming unit 14, the first additional word data group or the second additional word data group is inserted between words of the multiplexed eight-bit word string data DX(8) according to the timing signal STM in the following manner. The leading edge of the multiplexed eight-bit word string data DX(8) (indicated by C of FIG. 2) which is shifted backward by four word data from each of the eight-bit word data (A0 through A7), (B0 through B7), and so on, corresponding to the leading edge of the horizontal synchronous signal SH (represented by B of FIG. 2), is first specified according to the timing signal STM. Then, the four eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH are substituted with the first additional word data group consisting of the auxiliary word data DEB(8), the auxiliary word data DEA(8), the synchronous word data DEK(8), and the auxiliary word data DEC(8), or the second additional word data group consisting of the auxiliary word data DEC(8), the auxiliary word data DEA(8), the synchronous word data DEK(8), and the auxiliary word data DEC(8).

More specifically, if the RD of the eight-bit word data of the multiplexed eight-bit word string data DX(8) immediately before the leading edge of the timing signal STM, that is, the eight-bit word data which is shifted backward by five word data from the leading edge of each of the eight-bit word data (A0 through A7), (B0 through B7), and so on, corresponding to the leading edge of the horizontal synchronous signal SH, exhibits positive RD (+) when being converted into ten-bit word data, the aforementioned four eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH is substituted with the first additional word data group. In contrast, if the above-described eight-bit word data immediately before the leading edge of the timing signal STM exhibits negative RD (–) when being converted into ten-bit word data, the aforementioned four eight-bit word data is substituted with the second additional word data group.

Subsequently, according to the timing signal STM, 8B–10B conversion is performed on the multiplexed eight-bit word string data DX(8) provided with the first additional word data group or the second additional word data group, thereby forming the composite ten-bit word string data DZ(10). In this case, the synchronous word data DEK(8) is converted into K28.5, while the auxiliary word data DEA (8), DEB(8), and DEC(8) are converted into D21.3, D21.4, and D21.5, respectively.

The eight-bit word data (A0 through A7), (B0 through B7), etc., each having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, are converted into ten-bit word data (A'0 through A'9), (B'0 through B'9), etc. Then, eight-bit word data (A8 through A15), (A16 through A23), and so on, after the eight-bit word data (A0 through A7) are converted into ten-bit word data (A'10 through A'19), (A'20 through A'29), and so on, after the ten-bit word data (A'0 through A'9). Similarly, eight-bit word data (B8 through B15), (B16 through B23), and so on,

after the eight-bit word data (**B0** through **B7**) are converted into ten-bit word data (**B'10** through **B'19**), (**B'20** through **B'29**), and so on, after the ten-bit word data (**B'0** through **B'9**).

In the composite ten-bit word string data DZ(**10**) obtained as described above, as represented by D and E of FIG. **2**, the four ten-bit word data after the leading edge of the timing signal STM are used as four inserted word data based on the first additional word data group or the second additional word data group. If the RD of the ten-bit word data immediately before the leading edge of the timing signal STM is positive (+), the four inserted word data is based on the first additional word data group. In this case, the four inserted word data sequentially consists of −**D21.4** converted from the auxiliary word data DEB(**8**), **D21.3** converted from the auxiliary word data DEA(**8**), +**K28.5** converted from the synchronous word data DEK(**8**), and **D21.5** converted from the auxiliary word data DEC(**8**). Conversely, if the RD of the ten-bit word data immediately before the leading edge of the timing signal STM is negative (−), the four inserted word data is based on the second additional word data group. In this case, the four inserted word data sequentially consists of **D21.5** converted from the auxiliary word data DEC(**8**), **D21.3** converted from the auxiliary word data DEA(**8**), +**K28.5** converted from the synchronous word data DEK(**8**), and **D21.5** converted from the auxiliary word data DEC(**8**).

Hence, according to the composite ten-bit word string data DZ(**10**) formed by the ten-bit word string data forming unit **14**, the ten-bit synchronous word data having a positive RD, i.e., +**K28.5**, reliably exists at the position shifted backward by two word data from each of the ten-bit word data (**A'0** through **A'9**), (**B'0** through **B'9**), and so on, converted from the eight-bit word data (**A0** through **A7**), (**B0** through **B0** through **B7**), and so on, respectively, having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH. That is, the ten-bit word string data forming unit **14** selects the first additional word data group or the second additional word data group to be inserted between words of the multiplexed eight-bit word string data DX(**8**) so as to satisfy the above-described requirement. That is, the composite ten-bit word string data DZ(**10**) always contains +**K28.5** in the inserted four word data.

The resulting composite ten-bit word string data DZ(**10**) containing +**K28.5** is supplied to a parallel-to-serial (P/S) converter **18**, which forms a data transmitting unit. The composite ten-bit word string data DZ(**10**) is then converted into serial data DZS in the P/S converter **18**. Subsequently, the serial data DZS is transmitted from the P/S converter **18** via, for example, an optical transmitter. The optical transmitter converts the serial data DZS into a light signal, and transmits it to a data transmission channel, which is formed of an optical fiber.

In the foregoing embodiment, in the ten-bit word string forming unit **14**, the first additional word data group or the second additional word data group provided with four eight-bit word data containing the synchronous word data is inserted between words of the multiplexed eight-bit word string data DX(**8**) according to the timing signal STM. In the present invention, however, the number of eight-bit word data to be inserted into words of the multiplexed eight-bit word string data DX(**8**) is not limited to four, and may be two or three.

It is now assumed that in the ten-bit word string data forming unit **14**, the first additional word data group or the second additional word data group provided with three eight-bit word data containing the synchronous word data is inserted. In this case, the word data transmitter **16** may transmit the auxiliary word data DEB(**8**), the synchronous word data DEK(**8**), and the auxiliary word data DEC(**8**), while the word data transmitter **17** may transmit the auxiliary word data DEC(**8**), the synchronous word data DEK(**8**), and the auxiliary word data DEC(**8**). Then, the leading edge of the multiplexed eight-bit word string data DX(**8**) which is shifted by three word data from each of the eight-bit word data (**A0** through **A7**), (**B0** through **B7**), etc. having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, may be specified according to the timing signal STM. Subsequently, three eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH may be substituted with the first additional word data group sent from the word data transmitter **16** or the second additional word data group sent from the word data transmitter **17**.

In this case, if the eight-bit word data immediately before the leading edge of the timing signal STM, i.e., the eight-bit word data shifted by four word data from each of the eight-bit word data (**A0** through **A7**), (**B0** through **B7**), etc. having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, exhibits positive (+) RD when being converted into ten-bit word data, three eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH may be replaced with the first additional word data group. On the other hand, if the above-described eight-bit word data immediately before the leading edge of the timing signal STM exhibits negative (−) RD when being converted into ten-bit word data, the aforementioned three eight-bit word data may be replaced with the second additional word data group.

It is now assumed that in the ten-bit word string data forming unit **14**, the first additional word data group or the second additional word data group provided with two eight-bit word data containing the synchronous word data is inserted between words of the multiplexed eight-bit word string data DX(**8**). In this case, the word data transmitter **16** may transmit the auxiliary word data DEB(**8**) and the synchronous word data DEK(**8**), while the word data transmitter **17** may transmit the auxiliary word data DEC(**8**) and the synchronous word data DEK(**8**). Then, the leading edge of the multiplexed eight-bit word string data DX(**8**) which is shifted by two word data from each of the eight-bit word data (**A0** through **A7**), (**B0** through **B7**), etc. having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, may be specified according to the timing signal STM. Subsequently, two eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH may be substituted with the first additional word data group sent from the word data transmitter **16** or the second additional word data group sent from the word data transmitter **17**.

In this case, if the eight-bit word data immediately before the leading edge of the timing signal STM, i.e., the eight-bit word data shifted by three word data from each of the eight-bit word data (**A0** through **A7**), (**B0** through **B7**), etc. having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, exhibits positive (+) RD when being converted into ten-bit word data, two eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH may be replaced with the first

additional word data group. On the other hand, if the above-described eight-bit word data immediately before the leading edge of the timing signal STM exhibits negative (–) RD when being converted into ten-bit word data, the aforementioned two eight-bit word data may be replaced with the second additional word data group.

In the foregoing embodiment, the composite ten-bit word string data DZ(10), formed in the ten-bit word string data forming unit **14**, always contains a positive RD, i.e., +K28.5, in the first or second additional word data group. In the present invention, however, the composite ten-bit word string data DZ(10) may always contain a negative RD, i.e., –K28.5, in the first or second additional word data group.

In this modification, as well as in the foregoing embodiment, the number of eight-bit word data including the synchronous word data to be inserted between words of the multiplexed eight-bit word string data DX(8) by the ten-bit word string data forming unit **14** may also be four, three, or two.

It is now assumed that the composite ten-bit word string data DZ(10) always contains negative (–) RD, i.e., –K28.5, in the first or second additional word data group.

It is also assumed that four eight-bit word data including the synchronous word data are inserted as the first or second additional word data group between words of the eight-bit word string data DX(8). In this case, the word data transmitter **16** may send the auxiliary word data DEB(8), the auxiliary word data DEA(8), the synchronous word data DEK(8), and the auxiliary word data DEC(8), while the word data transmitter **17** may send the auxiliary word data DEC(8), the auxiliary word data DEA(8), the synchronous word data DEK(8), and the auxiliary word data DEC(8). Then, the leading edge of the multiplexed eight-bit word string data DX(8) which is shifted by four word data from each of the eight-bit word data (A0 through A7), (B0 through B7), and so on, having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, may be designated according to the leading edge of the timing signal STM. Thereafter, four eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH may be substituted with the first additional word data group transmitted from the word data transmitter **16** or the second additional word data group transmitted from the word data transmitter **17**.

In this case, if the eight-bit word data immediately before the leading edge of the timing signal STM, i.e., the eight-bit word data shifted by five word data from each of the eight-bit word data (A0 through A7), (B0 through B7), etc. having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, exhibits negative (–) RD when being converted into ten-bit word data, the four eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH may be substituted with the first additional word data group. Conversely, if the above-described eight-bit word data immediately before the leading edge of the timing signal STM exhibits positive (+) RD when being converted into ten-bit word data, the aforementioned four eight-bit word data may be substituted with the second additional word data group.

It is now assumed that the composite ten-bit word string data DZ(10) always contains negative (–) RD, i.e., –K28.5, in the first or second additional word data group. It is also assumed that three eight-bit word data including the synchronous word data are inserted between words of the multiplexed eight-bit word string data DX(8) according to the timing signal STM. In this case, the word data transmitter **16** may send the auxiliary word data DEB(8), the synchronous word data DEK(8), and the auxiliary word data DEC(8), while the word data transmitter **17** may send the auxiliary word data DEC(8), the synchronous word data DEK(8), and the auxiliary word data DEC(8). Then, the leading edge of the multiplexed eight-bit word string data DX(8) which is shifted by three word data from each of the eight-bit word data (A0 through A7), (B0 through B7), etc. having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, may be specified according to the leading edge of the timing signal STM. Thereafter, the three eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH may be substituted with the first additional word data group transmitted from the word data transmitter **16** or the second additional word data group transmitted from the word data transmitter **17**.

In this case, if the eight-bit word data immediately before the leading edge of the timing signal STM, i.e., the eight-bit word data shifted by four word data from each of the eight-bit word data (A0 through A7), (B0 through B7), etc. having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, exhibits negative (–) RD when being converted into ten-bit word data, the three eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH may be substituted with the first additional word data group. Conversely, if the above-described eight-bit word data immediately before the leading edge of the timing signal STM exhibits positive (+) RD when being converted into ten-bit word data, the aforementioned three eight-bit word data may be substituted with the second additional word data group.

It is now assumed that the composite ten-bit word string data DZ(10) always contains negative (–) RD, i.e., –K28.5, in the first or second additional word data group. It is also assumed that two eight-bit word data including the synchronous word data are inserted between words of the multiplexed eight-bit word string data DX(8) according to the timing signal STM. In this case, the word data transmitter **16** may send the auxiliary word data DEB(8) and the synchronous word data DEK(8), while the word data transmitter **17** may send the auxiliary word data DEC(8) and the synchronous word data DEK(8). Then, the leading edge of the multiplexed eight-bit word string data DX(8) which is shifted by two word data from each of the eight-bit word data (A0 through A7), (B0 through B7), and so on, having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, may be specified according to the leading edge of the timing signal STM. Subsequently, the two eight-bit word data positioned from the leading edge of the timing signal STM to the leading edge of the horizontal synchronous signal SH may be substituted with the first additional word data group transmitted from the word data transmitter **16** or the second additional word data group transmitted from the word data transmitter **17**.

In this case, if the eight-bit word data immediately before the leading edge of the timing signal STM, i.e., the eight-bit word data shifted by three word data from each of the eight-bit word data (A0 through A7), (B0 through B7), etc. having the leading edge corresponding to the leading edge of the horizontal synchronous signal SH, exhibits negative (–) RD when being converted into ten-bit word data, the two eight-bit word data positioned from the leading edge of the

timing signal STM to the leading edge of the horizontal synchronous signal SH may be replaced with the first additional word data group. In contrast, if the above-described eight-bit word data immediately before the leading edge of the timing signal STM exhibits positive (+) RD when being converted into ten-bit word data, the aforementioned two eight-bit word data may be replaced with the second additional word data group.

FIG. 4 is a block diagram illustrating a data receiving apparatus for receiving the serial data DZS based on the composite ten-bit word string data DZ(10) transmitted from the P/S converter 18 shown in FIG. 1.

In this data receiving apparatus, the serial data DZS based on the composite ten-bit word string data DZ(10) transmitted through a data transmission channel, formed of, for example, an optical fiber, is supplied. In a serial-to-parallel (S/P) converting and clock detecting unit 21, S/P conversion is performed on the serial data DZS, thereby forming parallel composite ten-bit word string data DZ(10), as represented by A of FIG. 5.

In the S/P converting and clock detecting unit 21, the clock is detected from the serial data DZS so as to reproduce a clock signal CLK. The reproduced clock signal CLK is supplied to a word clock generator 22, and three types of word clock signals CWB, CWC, and CWA based on the clock signal CLKare output from the word clock generator 22.

The composite ten-bit word string data DZ(10) obtained in the S/P converting and clock detecting unit 21 is supplied to an eight-bit word string data forming unit 23 and a synchronous word data detector 24. The synchronous word data detector 24 detects the ten-bit synchronous data having a positive RD, i.e., +K28.5, contained in the first or second additional word data group of the composite ten-bit word string data DZ(10), and then outputs a synchronous word data detection signal SKD, as indicated by B of FIG. 5.

The synchronous word data detection signal SKD obtained in the synchronous word data detector 24 is supplied to the word clock generator 22 and a synchronous signal forming unit 25. In the word clock generator 22, the phases of the word clock signals CWB, CWC, and CWA are determined by the synchronous word data detection signal SKD. In the synchronous signal forming unit 25, a synchronous signal SS is formed based on the synchronous word data detection signal SKD.

Supplied to the eight-bit word string data forming unit 23 are not only the composite ten-bit word string data DZ(10) from the S/P converting and clock detecting unit 21, but also the word clock signals CWB and CWC sent from the word clock generator 22. Then, in the eight-bit word string data forming unit 23, 10B–8B conversion is conducted on the composite ten-bit word string data DZ(10) based on the word clock signals CWB and CWC, thereby forming composite eight-bit word string data DZ(8) based on the composite ten-bit word string data DZ(10).

In this case, the ten-bit word data (A'0 through A'9), (A'10 through A'19), (A'20 through A'29), and so on, and (B'0 through B'9), (B'10 through B'19), (B'20 through B'29), and so on, are respectively converted into (A0 through A7), (A8 through A15), (A16 through A23), etc., and (B0 through B7), (B8 through B15), (B16 through B23), etc. Additionally, the ten-bit word data, i.e., –D21.4, D21.3, and D21.5, and the ten-bit synchronous word data, i.e., +K28.5, contained in the first additional word data group of the composite ten-bit word string data DZ(10) are converted into the auxiliary word data DEB(8), the auxiliary word data DEA(8), the auxiliary word data DEC(8), and the synchronous word data DEK(8), respectively. The ten-bit word data, i.e., D21.5, D21.3, and D21.5, and the ten-bit synchronous word data, i.e., +K28.5, contained in the second additional word data group of the composite ten-bit word string data DZ(10) are converted into the auxiliary word data DEC(8), the auxiliary word data DEA(8), the auxiliary word data DEC(8), and the synchronous word data DEK(8), respectively. All of the converted eight-bit word data are contained in the composite eight-bit word string data DZ(8).

The composite eight-bit word string data DZ(8) obtained from the eight-bit word string data forming unit 23 is supplied to a data separator 26. The synchronous signal SS generated based on the synchronous word data detection signal SKD in the synchronous signal forming unit 25 is also supplied to the data separator 26. The data separator 26 then separates the following data from the composite eight-bit word string data DZ(8) based on the synchronous signal SS corresponding to the ten-bit synchronous word data, i.e., +K28.5: the multiplexed eight-bit word string data DX(8), the auxiliary word data DEB(8), the auxiliary word data DEA(8), the synchronous word data DEK(8), and the auxiliary word data DEC(8), the four data forming the first additional word data group; and the auxiliary word data DEC(8), the auxiliary word data DEA(8), the synchronous word data DEK(8), and the auxiliary word data DEC(8), the four data forming the second additional word data group.

The multiplexed eight-bit word string data DX(8) separated by the data separator 26 is supplied to a ten-bit word string data forming unit 27. The word clock signals CWC and CWB generated by the word clock generator 22 are supplied to the ten-bit word string data forming unit 27. Thus, in the ten-bit word string data forming unit 27, 8B–10B conversion is performed on the multiplexed eight-bit word string data DX(8) based on the word clock signals CWC and CWB, thereby forming the multiplexed ten-bit word string data DZ(10) based on the multiplexed eight-bit word string data DX(8).

The multiplexed ten-bit word string data DZ(10) obtained from the ten-bit word string data forming unit 27 is supplied to a data reproducing unit 28. The word clock signals CWC and CWB generated by the word clock generator 22 are also supplied to the data reproducing unit 28. In the data reproducing unit 28, the multiplexed ten-bit word string data DZ(10) is separated into ten-bit word string data SVA(10), SVB(10), and SVC(10), representing three types of video signal information, based on the word clock signals CWC and CWB. The ten-bit word string data SVA(10), SVB(10), and SVC(10) are then individually output from the data reproducing unit 28.

In the data receiving apparatus shown in FIG. 4, the serial data DZS converted from the composite ten-bit word string data DZ(10) containing the ten-bit synchronous word data always having a positive RD, i.e., +K28.5, is received, thereby reproducing the ten-bit word string data SVA(10), SVB(10), and SVC(10). Thus, the word synchronous data detector 24 detects +K28.5. Alternatively, the serial data DZS converted from the composite ten-bit word string data DZ(10) containing the ten-bit synchronous word data always having a negative RD, i.e., –K28.5, may be received. In this case, a data receiving apparatus for receiving such serial data DZS may be constructed similarly to that shown in FIG. 4, except that the synchronous word data detector 24 detects the ten-bit synchronous word data having a negative RD, i.e., –K28.5.

What is claimed is:

1. A data transmission method comprising:

a receiving step of receiving eight-bit word string data indicating signal information;

an insertion step of inserting an additional word data group including specific synchronous word data and at least one item of auxiliary word data, each data having eight bits and a predetermined code, between words of the eight-bit word string data in accordance with a predetermined timing signal;

a conversion step of converting the eight-bit word string data provided with the additional word data group into ten-bit word string data;

a forming step of forming composite ten-bit word string data including the additional word data group containing ten-bit synchronous word data which is converted from the specific synchronous word data; and

a transmission step of transmitting the composite ten-bit word string data,

wherein in said insertion step, the additional word data group is selected so that a running disparity of the ten-bit synchronous word data contained in the additional word data group of the composite ten-bit synchronous word data is consistently one of positive and negative.

2. A data transmission method according to claim 1, wherein in said insertion step, the additional word data group is selected so that the running disparity of the ten-bit synchronous word data contained in the additional word data group of the composite ten-bit synchronous word data is consistently positive.

3. A data transmission method according to claim 2, wherein the additional word data group of the composite ten-bit word string data includes ten-bit word data having a negative running disparity, ten-bit word data having a neutral running disparity, and ten-bit synchronous word data, or includes the ten-bit word data having a negative running disparity and the ten-bit synchronous word data when the running disparity of ten-bit word data positioned immediately before the additional word data group is positive, and wherein the additional word data group of the composite ten-bit word string data includes ten-bit word data having a neutral running disparity, another ten-bit word data having a neutral running disparity, and the ten-bit synchronous word data, or includes the ten-bit word data having a neutral running disparity and the ten-bit synchronous word data when the running disparity of ten-bit word data positioned immediately before the additional word data group is negative.

4. A data transmission method according to claim 3, wherein the additional word data group of the composite ten-bit word string data includes another ten-bit word data after the ten-bit synchronous word data.

5. A data transmission method according to claim 1, wherein in said insertion step, the additional word data group is selected so that the running disparity of the ten-bit synchronous word data contained in the additional word data group of the composite ten-bit synchronous word data is consistently negative.

6. A data transmission method according to claim 5, wherein the additional word data group of the composite ten-bit word string data includes ten-bit word data having a positive running disparity, ten-bit word data having a neutral running disparity, and ten-bit synchronous word data, or includes the ten-bit word data having a positive running disparity and the ten-bit synchronous word data when the running disparity of ten-bit word data positioned immediately before the additional word data group is negative, and wherein the additional word data group of the composite ten-bit word string data includes ten-bit word data having a neutral running disparity, another ten-bit word data having a neutral running disparity, and the ten-bit synchronous word data, or includes the ten-bit word data having a neutral running disparity and the ten-bit synchronous word data when the running disparity of ten-bit word data positioned immediately before the additional word data group is positive.

7. A data transmission method according to claim 6, wherein the additional word data group of the composite ten-bit word string data includes another ten-bit word data after the ten-bit synchronous word data.

8. A data transmission method according to claim 1, wherein the composite ten-bit word string data is converted into serial data, and the serial data is transmitted.

9. A data transmission method according to claim 8, wherein the serial data is transmitted through a data transmission channel formed of an optical fiber.

10. A data transmission method according to claim 1, wherein the eight-bit word string data represents video signal information, and the timing signal used for inserting the additional word data group between the words of the eight-bit word string data is synchronized with each horizontal period of the video signal information.

11. A data transmission apparatus comprising:

a digital data forming unit for forming eight-bit word string data indicating signal information;

a ten-bit word string data forming unit for inserting an additional word data group including specific synchronous word data and at least one item of auxiliary word data, each data having eight bits and a predetermined code, between words of the eight-bit word string data in accordance with a predetermined timing signal, and for converting the eight-bit word string data provided with the additional word data group into ten-bit word string data, thereby forming composite ten-bit word string data including the additional word data group containing ten-bit synchronous word data which is converted from the specific synchronous word data; and

a data transmitting unit for transmitting the composite ten-bit word string data,

wherein said ten-bit word string data forming unit inserts the additional word data group between the words of the eight-bit word string data so that a running disparity of the ten-bit synchronous word data contained in the additional word data group of the composite ten-bit synchronous word data is consistently one of positive and negative.

12. A data transmission apparatus according to claim 11, wherein said ten-bit word string data forming unit inserts the additional word data group between the words of the eight-bit word string data so that the running disparity of the ten-bit synchronous word data contained in the additional word data group of the composite ten-bit synchronous word data is consistently positive.

13. A data transmission apparatus according to claim 12, wherein said ten-bit word string data forming unit comprises a word data transmitter for supplying the additional word data group.

14. A data transmission apparatus according to claim 13, wherein said word data transmitter supplies the additional word data group to said ten-bit word string data forming unit so that the additional word data group of the composite

ten-bit word string data includes ten-bit word data having a negative running disparity, ten-bit word data having a neutral running disparity, and ten-bit synchronous word data, or includes the ten-bit word data having a negative running disparity and the ten-bit synchronous word data when the running disparity of ten-bit word data positioned immediately before the additional word data group is positive, and wherein said word data transmitter supplies the additional word data group to said ten-bit word string data forming unit so that the additional word data group of the composite ten-bit word string data includes ten-bit word data having a neutral running disparity, another ten-bit word data having a neutral running disparity, and the ten-bit synchronous word data, or includes the ten-bit word data having a neutral running disparity and the ten-bit synchronous word data when the running disparity of ten-bit word data positioned immediately before the additional word data group is negative.

15. A data transmission apparatus according to claim **14**, wherein said word data transmitter supplies the additional word data group to said ten-bit word string data forming unit so that the additional word data group further includes another ten-bit word data after the ten-bit synchronous word data.

16. A data transmission apparatus according to claim **11**, wherein said ten-bit word string data forming unit inserts the additional word data group between the words of the eight-bit word string data so that the running disparity of the ten-bit synchronous word data contained in the additional word data group of the composite ten-bit synchronous word data is consistently negative.

17. A data transmission apparatus according to claim **16**, wherein said ten-bit word string data forming unit comprises a word data transmitter for supplying the additional word data group.

18. A data transmission apparatus according to claim **17**, wherein said word data transmitter supplies the additional word data group to said ten-bit word string data forming unit so that the additional word data group of the composite ten-bit word string data includes ten-bit word data having a positive running disparity, ten-bit word data having a neutral running disparity, and ten-bit synchronous word data, or includes the ten-bit word data having a positive running disparity and the ten-bit synchronous word data when the running disparity of ten-bit word data positioned immediately before the additional word data group is negative, and wherein said word data transmitter supplies the additional word data group to said ten-bit word string data forming unit so that the additional word data group of the composite ten-bit word string data includes ten-bit word data having a neutral running disparity, another ten-bit word data having a neutral running disparity, and the ten-bit synchronous word data, or includes the ten-bit word data having a neutral running disparity and the ten-bit synchronous word data when the running disparity of ten-bit word data positioned immediately before the additional word data group is positive.

19. A data transmission apparatus according to claim **18**, wherein said word data transmitter supplies the additional word data group to said ten-bit word string data forming unit so that the additional word data group further includes another ten-bit word data after the ten-bit synchronous word data.

20. A data transmission apparatus according to claim **11**, wherein said data transmitting unit converts the composite ten-bit word string data into serial data, and transmits the serial data.

21. A data transmission apparatus according to claim **20**, wherein said data transmitting unit transmits the serial data to a data transmission channel which is formed of an optical fiber.

22. A data transmission apparatus according to claim **11**, wherein the eight-bit word string data obtained from said digital data forming unit represents video signal information, and the timing signal used for inserting the additional word data group between the words of the eight-bit word string data by said ten-bit word string data forming unit is synchronized with each horizontal period of the video signal information.

* * * * *

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Yamashita

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(45) **Date of Patent: Nov. 27, 2001**

(54) **DATA TRANSMISSION METHOD AND DEVICE**

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(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/558,011**

(22) Filed: **Apr. 25, 2000**

Related U.S. Application Data

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(30) **Foreign Application Priority Data**

Nov. 22, 1996 (JP) 08-312276

(51) **Int. Cl.**[7] **H03M 5/00**; H03M 7/00

(52) **U.S. Cl.** **341/58**; 341/59; 341/95; 375/292

(58) **Field of Search** 341/58, 59, 95; 375/292

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,486,739 * 12/1984 Franaszek et al. 341/59
4,517,552 * 5/1985 Shirota et al. 341/58
5,229,769 * 7/1993 Gleichert 341/58
5,304,996 * 4/1994 Hsu et al. 341/58
5,387,911 * 2/1995 Gleichert et al. 341/58
5,570,089 * 10/1996 Haas 341/58
5,592,160 * 1/1997 Bennett et al. 341/58
5,699,062 * 12/1997 Widmer 341/58
5,825,824 * 10/1998 Lee et al. 341/58

* cited by examiner

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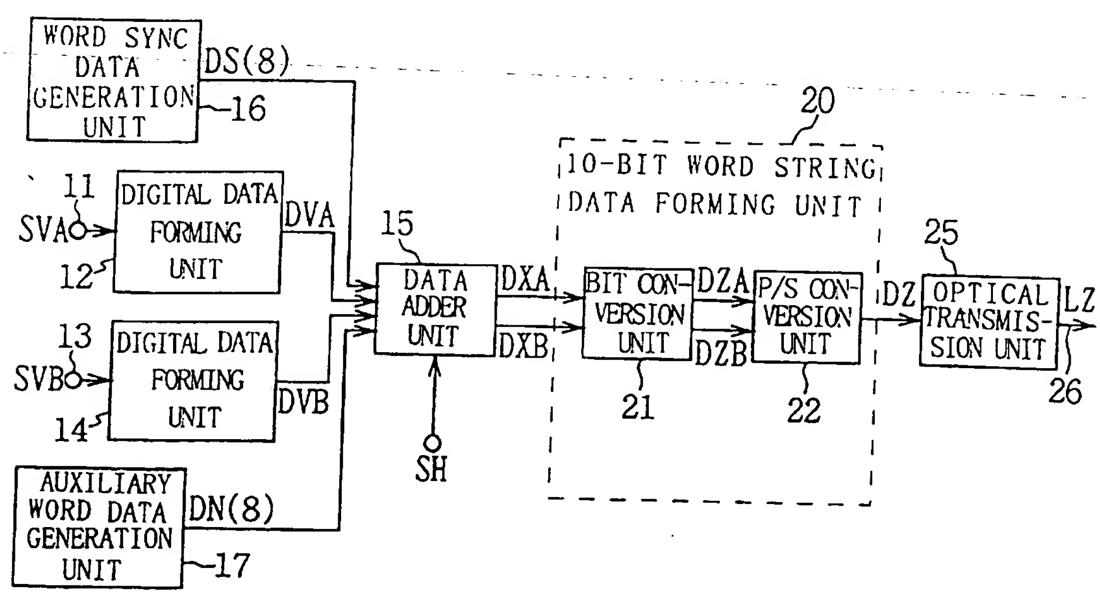
Assistant Examiner—Jean Bruner JeanGlaude
(74) *Attorney, Agent, or Firm*—Bell, Boyd & Lloyd LLC

(57) **ABSTRACT**

In the case of transmitting upon converting the 8-bit word string data showing signal information to the 10-bit word string data consisting of word synchronous data, 8-bit word string data showing signal information is obtained and after inserting 2 each of the 8-bit word synchronous data and the 8-bit auxiliary word data to be converted to the 10-bit neutral word data, 8 to 10 bits conversion is conducted to the 10-bit word string data and transmitted; when converting the 8-bit word synchronous data to 10-bit word synchronous data, if the immediately preceding word data is the data having plus running disparity, it is converted to 10-bit word synchronous data having minus running disparity, and if the immediately preceding word data is the data having minus running disparity, it is converted to the 10-bit word synchronous data having plus running disparity. Thereby, in the case of reproducing the signal information at the receiving end, the necessary signal synchronization can be certainly obtained.

4 Claims, 6 Drawing Sheets



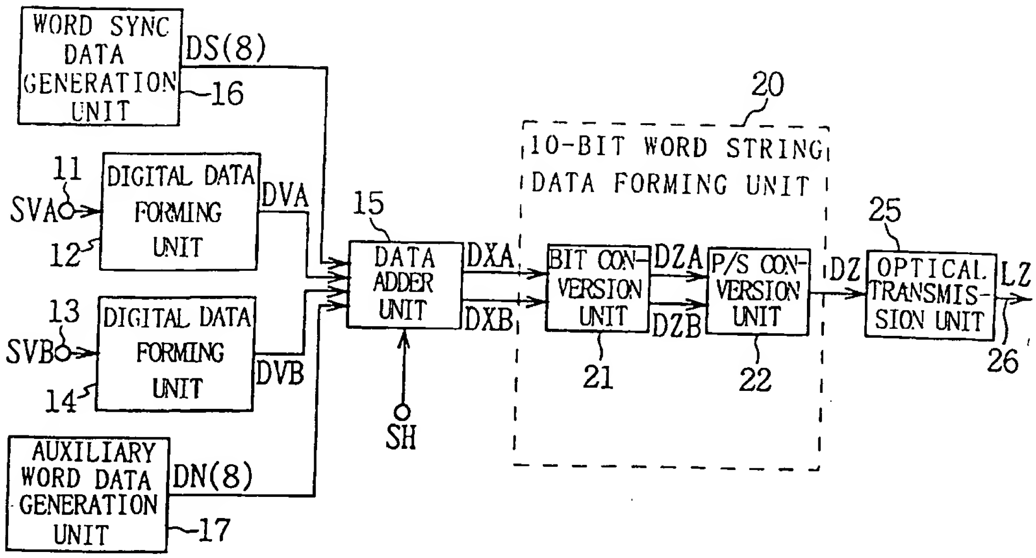

WORD SYNC DATA GENERATION UNIT
DS(8)
16
11
SVA
12
DIGITAL DATA FORMING UNIT
DVA
13
SVB
14
DIGITAL DATA FORMING UNIT
DVB
AUXILIARY WORD DATA GENERATION UNIT
DN(8)
17
15
DATA ADDER UNIT
SH
DXA
DXB
20
10-BIT WORD STRING DATA FORMING UNIT
BIT CONVERSION UNIT
21
DZA
DZB
P/S CONVERSION UNIT
22
DZ
25
OPTICAL TRANSMISSION UNIT
LZ
26

FIG. 1

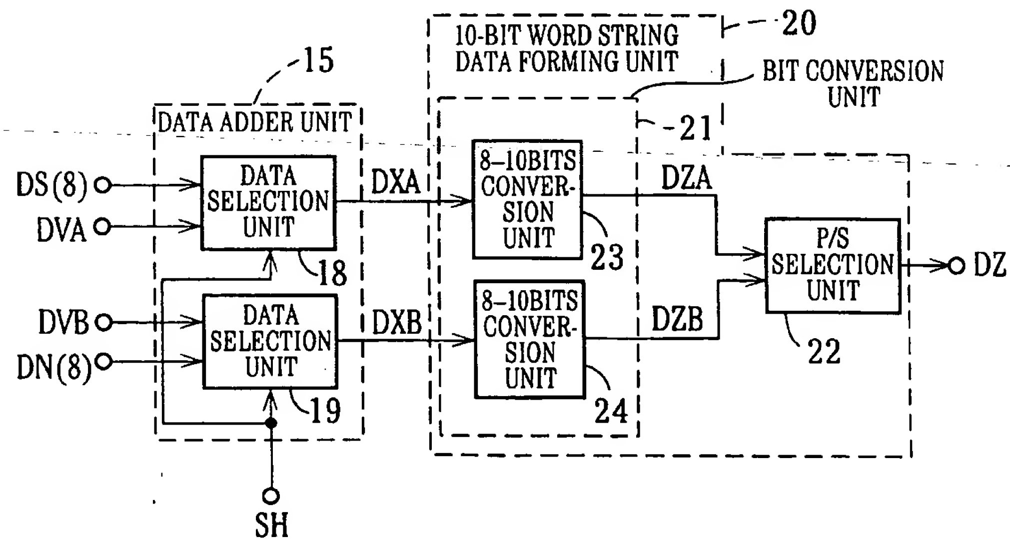

15
DATA ADDER UNIT
DS(8)
DVA
DATA SELECTION UNIT
18
DVB
DN(8)
DATA SELECTION UNIT
19
SH
DXA
DXB
10-BIT WORD STRING DATA FORMING UNIT
20
BIT CONVERSION UNIT
21
8–10BITS CONVERSION UNIT
23
8–10BITS CONVERSION UNIT
24
DZA
DZB
P/S SELECTION UNIT
22
DZ

FIG. 2

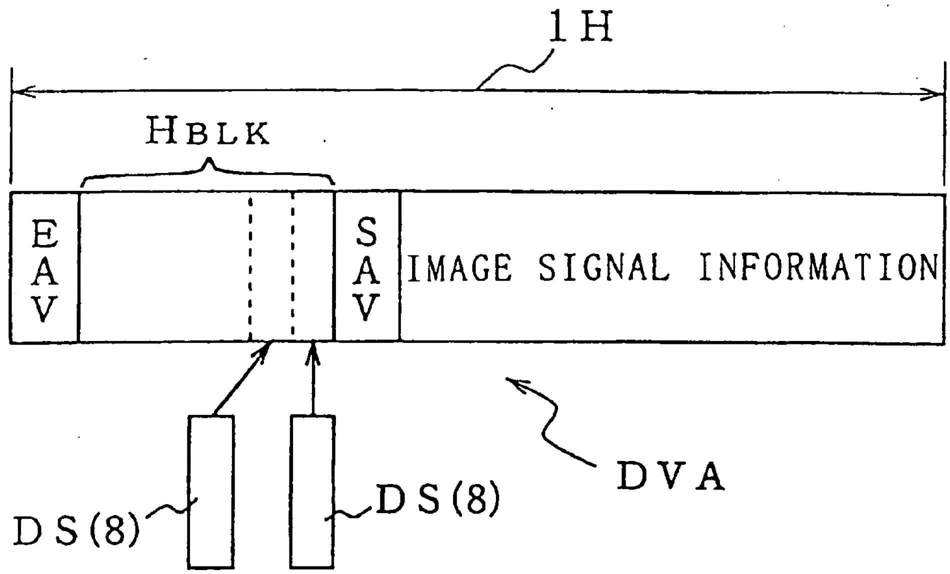

1H
HBLK
EAV
SAV
IMAGE SIGNAL INFORMATION
DVA
DS(8)
DS(8)

FIG.3B

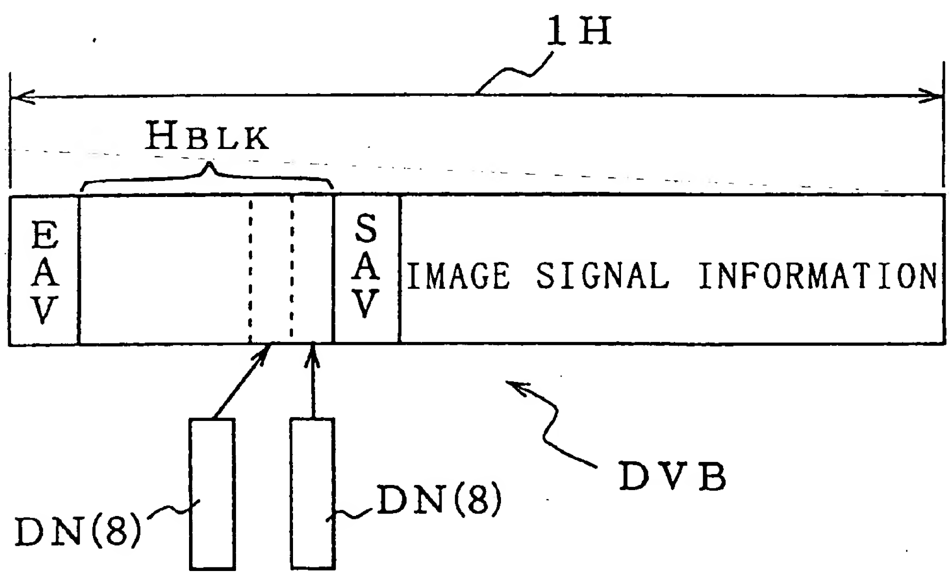

1H
HBLK
EAV
SAV
IMAGE SIGNAL INFORMATION
DVB
DN(8)
DN(8)

FIG.3A

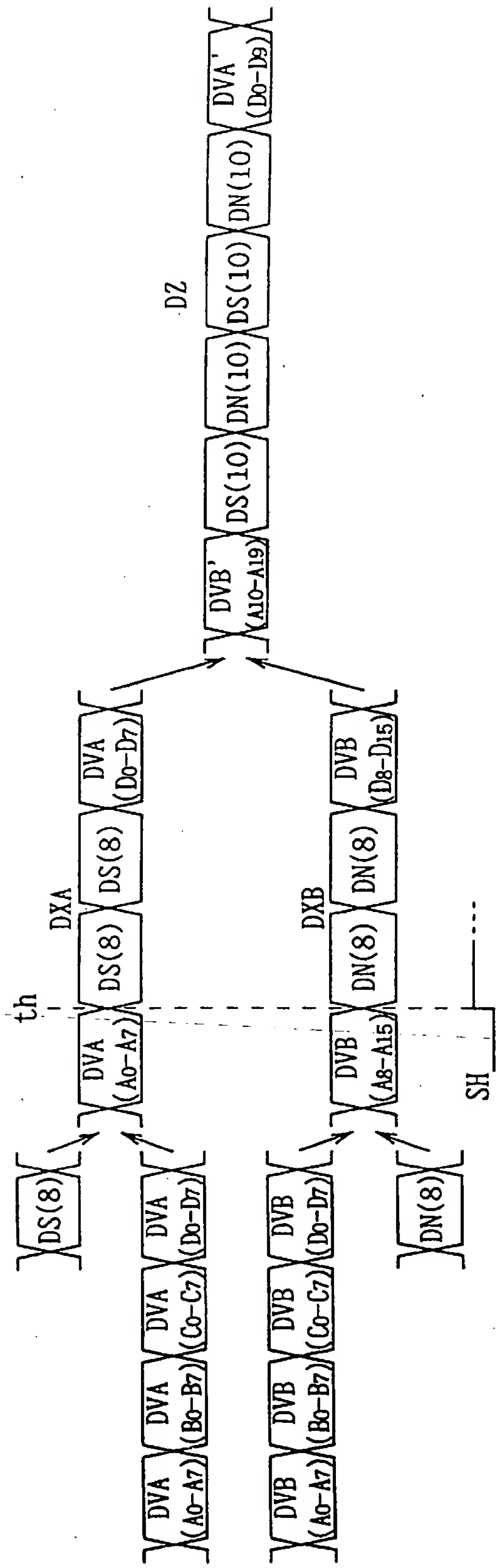

DVA (A0-A7)
DVA (B0-B7)
DVA (C0-C7)
DVA (D0-D7)
DS(8)
DVB (A0-A7)
DVB (B0-B7)
DVB (C0-C7)
DVB (D0-D7)
DN(8)
th
DXA
DVA (A0-A7)
DS(8)
DS(8)
DVA (D0-D7)
DXB
DVB (A8-A15)
DN(8)
DN(8)
DVB (D8-D15)
SH
DZ
DVB' (A10-A19)
DS(10)
DN(10)
DS(10)
DN(10)
DVA' (D0-D9)

FIG. 4

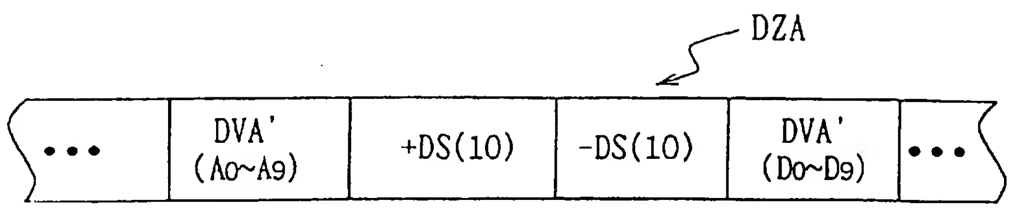


FIG.5A

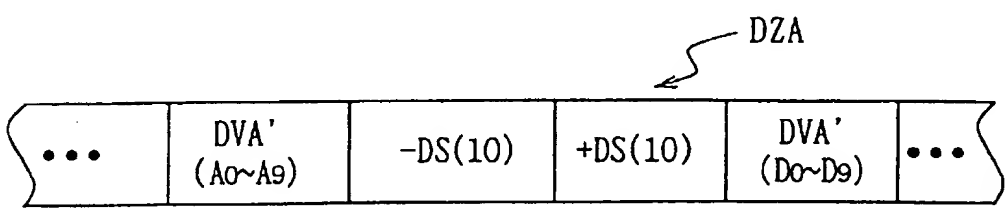


FIG.5B

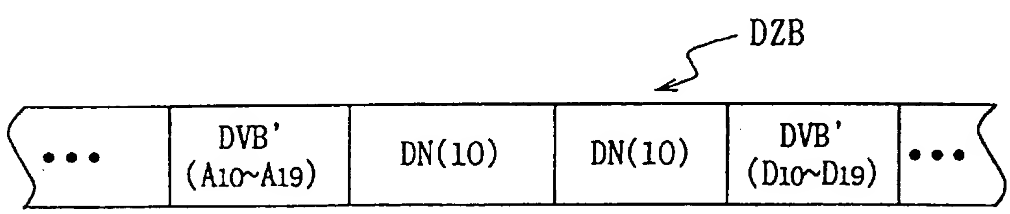


FIG.5C

		CRD	-	+
DN(8)	000 00001	DN(10)	011101 0100	100010 1011

FIG. 6

	(+DS(10))	(DN(10))	(-DS(10))	(DN(10))	
DVB' (A_{10}~A_{19})	001111 1010	100010 1011 (011101 0100)	110000 0101	011101 0100 (100010 1011)	DVA' (D_0~D_9)
RD:-	+	(±)	-	(±)	

FIG.7A

	(-DS(10))	(DN(10))	(+DS(10))	(DN(10))	
DVB' (A_{10}~A_{19})	110000 0101	011101 0100 (100010 1011)	001111 1010	100010 1011 (011101 0100)	DVA' (D_0~D_9)
RD:+	-	(±)	+	(±)	

FIG.7B

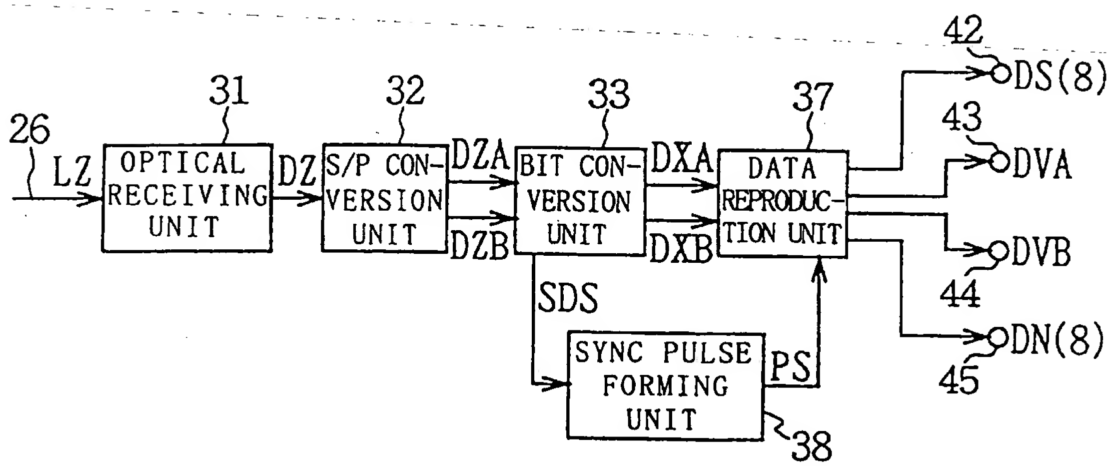


FIG. 8

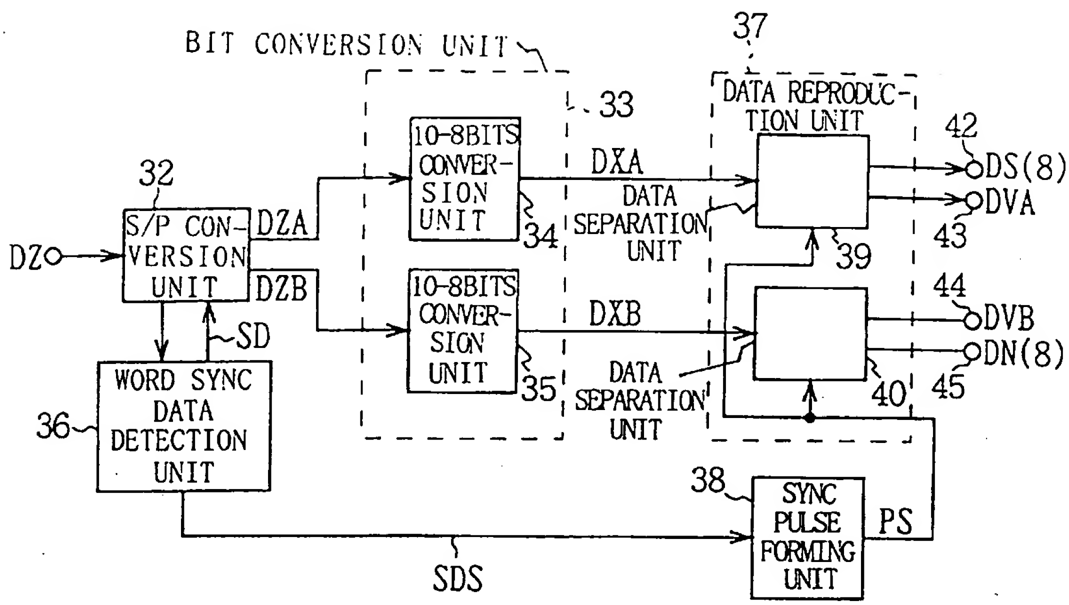


FIG. 9

CRD	−	+
DS(10)	001111 1010	110000 0101

FIG. 10

DATA TRANSMISSION METHOD AND DEVICE

This application is a continuation of Ser. No. 09/120,852 filed Jul. 22, 1998, U.S. Pat. No. 6,054,944 which is a continuation of PCT/JP97/04263 filed Nov. 21, 1997.

TECHNICAL FIELD

The present invention relates to a data transmission method and device for converting 8 bits word string data representing signal information such as image signal information to 10 bits word string data containing word synchronous data and transmitting to a transmission path.

BACKGROUND ART

As a transmission mode of digital data showing various signal information, an optical transmission system which converts digital data to an optical signal and transmits via transmission path formed by using optical fiber has been proposed. The digital data to be processed under such optical transmission system is serial data having the bit rate of approximately from several hundreds (Mbps) to one (Gbps).

The digital data to be processed under the optical transmission system is converted from 8-bit word string data in which 1 word is formed with 8 bits into 10 bits word string data in which 1 word is formed with 10 bits , that is 8–10 bit conversion is conducted at the transmitting end and transmitted as 10-bit word string data. Then, at the receiving end, 10–8 bit word string data conversion that converts the 10-bit word string data received to the former 8-bit word string data is conducted.

Every word having 10 bits in the 10-bit word string data used in the transmission system is categorized in terms of the number of ones and zeros; i.e., the number of ones is larger than the number of zeros, the number of zeros is larger than the number of ones, and the equal numbers of ones and zeros are present. In this connection, in order to indicate the condition of the number of ones and zeros, the idea of running disparity (RD) is adopted; it is called that when the number of ones is larger than the number of zeros, the running disparity (RD) is plus, and when the number of zeros is larger than the number of ones, the RD is minus, and moreover, when the number of ones and the number of zeros are the same, the RD is neutral. And the word data having more ones than zeros is called as the word data having plus RD (plus word data), the word data having more zeros than ones is called as the word data having minus RD (minus word data), and the word data having the equal number of ones and zeros is called as the word data having neutral RD (neutral word data).

Furthermore, in the case of transmitting 10-bit word string data, considering the word synchronization that divides serial data per 10-bit word correctly at the receiving end, word synchronous data will be inserted as required. This word synchronous data is the word consisting of 10 bits but this word is the word having special code that can not be used as the 10-bit word to conduct the information transmission. In the case where the word synchronous data is being assigned, if the immediately preceding word data is the data having minus RD, it is considered that the word synchronous data has plus RD, and if the immediately preceding word data has plus RD, it is considered that the word synchronous data has minus RD.

FIG. 10 shows an example of 10-bit word synchronous data DS (10), and when the immediately preceding word data has minus (−) RD, i.e., CRD (current running disparity),

the word synchronous data DS (10) is considered as "001111 1010" having plus RD, and when the immediately preceding word data has plus (+) CRD, the word synchronous data DS (10) is considered as "110000 0101" having minus RD (hereinafter "001111 1010" is referred to as the word synchronous data +DS (10), and "110000 0101" is referred to as the word synchronous data −DS (10)).

These examples of word synchronous data "001111 1010" and "110000 0101" are defined as the code name K28.5 based on the fiber channel standard ANSI X3.230-1994.

When the 10-bit word string data to be transmitted under the above condition is regarded as the data showing image signal information, it is considered that 10-bit word can be correctly divided using the word synchronous data at each horizontal interval at the receiving end by inserting word synchronous data at each horizontal interval of the image signal.

In this case, either the word synchronous data +DS (10) having plus RD or the word synchronous data −DS (10) having minus RD will be inserted at each horizontal interval of image signal depending upon whether the RD of the immediately preceding word data is minus or plus at the transmitting end.

For example, in the case of inserting the word synchronous data at the transmitting end, if the RD of the immediately preceding word data is minus, plus word synchronous data +DS (10) is inserted, and when the RD of the immediately preceding word data is plus, minus word synchronous data −DS (10) is inserted.

The image signal information in which word synchronous data is inserted is converted from 20-bit parallel data to serial data and transmitted from the transmitting end to the receiving end, and word synchronous data is extracted from the 10-bit word string data at the receiving end, and thus dividing the serial transmission data per 10-bit word, it is considered that the serial data can be correctly divided per 10-bit word at each horizontal interval in which said word synchronous data is inserted.

In the case of detecting the word synchronous data, the receiving end that sequentially receives 10-bit word string data of the image signal information (serial data) to which the word synchronous data +DS (10) or −DS (10) has been assigned at each horizontal interval of the image signal information at the transmitting end, only detects plus word synchronous data +DS (10) but does not detect minus word synchronous data −DS (10).

However, if the word synchronous data detection at the receiving end only detects the word synchronous data +DS (10) and not detect the word synchronous data −DS (10), there causes an inconvenience in conducting the data processing at the receiving end, since either the word synchronous data having plus RD +DS (10) or having minus RD −DS (10) is inserted depending upon the RD condition of the immediately preceding word data, i.e., the RD of the immediately preceding data is minus or plus, at each part corresponding to the horizontal synchronization in image signal.

More specifically, since the receiving end only detects the word synchronous data +DS (10) and does not detect the word synchronous data −DS (10) when conducting the processing of 10-bit word string data, the condition in which word synchronous data detection can be conducted at the part corresponding to the horizontal interval in the image signal information can not be secured, and as a result, when reproducing the image signal information represented by 10-bit word string data, it caused a problem that the correct word synchronization at each horizontal interval could not be obtained.

DISCLOSURE OF THE INVENTION

The present invention has been done considering the above points and is proposing a data transmission method and data transmission device capable of obtaining the condition by which required signal synchronous condition can be certainly secured when reproducing the signal information represented by 10-bit word string data at the receiving end, when transmitting the 10-bit word string data after converting the 8-bit word string data representing signal information such as image signal information to the 10-bit word string data consisting of both the word synchronous data having plus RD and the word synchronous data having the minus RD even if the word synchronous data detection at the receiving end detects only word synchronous data having plus RD.

The transmission method according to the present invention, after obtaining 8-bit word string data representing the signal information, 2 each of the 8-bit word synchronous data having preset code and the 8-bit auxiliary word data to be converted to the 10-bit neutral word data will be inserted between words in the 8-bit word string data corresponding to the predetermined timing signal; and the 8-bit word string data in which the 8-bit word synchronous data and the 8-bit word string data in which 8-bit auxiliary word data are inserted will be converted to 10-bit word string data, and composite 10-bit word synchronous data having the part to which two 10-bit word synchronous data and 10-bit neutral word data are allocated alternately and this composite 10-bit word string data will be transmitted so that when converting the 8-bit word string data to the 10-bit word string data, the 8-bit word synchronous data will be converted to the 10-bit word synchronous data having minus RD if the immediately preceding word data has the plus RD; and if the immediately preceding word data has the minus RD, converted to the 10-bit word synchronous data having the plus RD.

Furthermore, the transmission device according to the present invention comprises a digital data forming unit for obtaining 8-bit word string data showing signal information, a word synchronous data generation unit for outputting 8-bit word synchronous data having preset code, an auxiliary word data generating unit for outputting the 8-bit auxiliary word data to be converted to the 10-bit neutral word data, a data adder unit for allocating two 8-bit word synchronous data and 8-bit auxiliary word data between words in the 8-bit word string data obtained from the digital data forming unit according to the predetermined timing signal; a 10-bit word string data forming unit which converts the 8-bit word synchronous data obtained from the data adder unit and the 8-bit word string data in which 8-bit auxiliary word data is inserted to 10-bit word string data and simultaneously obtains the composite 10-bit word string data having the part to which two 10-bit word synchronous data based on the 8-bit word synchronous data and the 10-bit neutral word data based on the 8-bit auxiliary word data are allocated alternately in succession; and a data transmission unit for outputting the composite 10-bit word string data; and in the case where the 10-bit word string data forming unit converts the 8-bit word string data to the 10-bit word string data, the 8-bit word synchronous data is converted to the 10-bit word synchronous data having the minus RD when the immediately preceding word data has the plus RD, and when the immediately preceding word data has the minus RD, the 8-bit word synchronous data is converted to the 10-bit word synchronous data having the plus RD.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram showing an ample of the data transmission device and its method according to the present invention.

FIG. **2** is a block diagram showing the detailed construction of the part including a data adder unit and 10-bit word string data forming unit shown in the example of FIG. **1**.

FIG. **3** is a diagrammatic sketch showing an image signal information for one horizontal interval and horizontal blanking interval.

FIG. **4** is a data block diagram illustrating the operation of the example shown in FIG. **1**.

FIG. **5** is a data block diagram illustrating the operation of the example shown in FIG. **1**.

FIG. **6** is a schematic diagram illustrating the operation of the bit conversion unit in the example shown in FIG. **1**.

FIG. **7** is a schematic diagram illustrating the operation of the P/S conversion unit in the example shown in FIG. **1**.

FIG. **8** is a block diagram showing an example of the data receiving device that receives the data transmitted from the data transmission device according to the present invention.

FIG. **9** is a block diagram showing the detailed construction of the part including the bit conversion unit and the data reproduction unit according to the example shown in FIG. **8**.

FIG. **10** is a schematic diagram illustrating the word synchronous data to be used in the digital data transmission.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows an example of data transmission device and its method according to the present invention.

In the example shown in FIG. **1**, image signal SVA of the first channel is supplied to a digital data forming unit **12** via an image signal terminal **11** and image signal SVB of the second channel is supplied to a data forming unit **14** via an image signal terminal **13**. In general, the content of image information that the image signal SVA shows is different from those of the image signal SVB shows.

In the digital data forming unit **12**, an analog/digital conversion is conducted on the image signal SVA and 8-bit word string data DVA showing image signal information based on the image signal SVA is formed. This 8-bit word string data DVA forms digital data of the image signal SVA by arranging 8-bit word data SVA.

Similarly, in the digital data forming unit **14**, analog/digital conversion is conducted on the image signal SVB and 8-bit word string data DVB showing image signal information based on the image signal SVB is formed. This 8-bit word string data DVB forms digital data of the image signal SVB by arranging 8-bit word data.

Then, the 8-bit word string data DVA obtained from the digital data forming unit **12** and the 8-bit word string data obtained from the digital data forming unit **14** will be supplied to a data adder unit **15**. The 8-bit word string data DVA and the 8-bit word string data DVB are in synchronism with each other.

Furthermore, in the example shown in FIG. 1, a word data generating unit **16** for transmitting 8-bit word synchronous data DS (8) and an auxiliary word data generating unit **17** to transmit 8-bit auxiliary word data DN (8) are provided. And the word synchronous data DS (8) from the word synchronous data generating unit **16** and the auxiliary word data DN(8) from the auxiliary word data generating unit **17** are supplied to the data adder unit **15**.

At the time when the 8-bit word synchronous data DS (8) is given the 8 to 10 bits conversion for example, it has a specific code that makes the DS (8) to be converted either to the word synchronous data +DS (10) which is the 10-bit

word synchronous data DS (10) having plus RD, i.e., "001111 1010", or the word synchronous data –DS (10) which is the 10-bit word synchronous data DS (10) having minus RD, i.e., "110000 0101". The code of 8-bit word synchronous data DS (8) cannot be used as the code for the word data forming 8-bit word string data DVA and DVB.

On the other hand, the 8-bit auxiliary word data DN (8), for example, when it is being given the 8–10 bits conversion, it is converted to the neutral word data DN (10) formed with 10 bits that is defined by the fiber channel standard and selected to "000 0000111", for example.

In the data adder unit **15**, timing signal SH that corresponds to the horizontal synchronizing signal in the image signal SVA or image signal SVB and synchronizes to the part corresponding to horizontal interval (horizontal interval part) in the 8-bit word string data DVA and the 8-bit word string data DVB showing the image signal information will be also supplied.

The data adder unit **15** is comprised of data selection units **18** and **19** as shown in FIG. **2**, for example. In the data selection unit **18**, 8-bit word string data DVA from the digital data forming unit **12**, 8-bit word synchronous data DS (8) from the word synchronous data generation unit **16**, and the timing signal SH will be supplied; and the 8-bit word string data DVB from the digital data forming unit **14**, the 8-bit auxiliary word data DN (8) from the auxiliary word data generation unit **17**, and the timing signal SH will be supplied to the data selection unit **19**.

Then, in the data selection unit **18**, as shown in FIG. **3**(A), inactive data for 2 words allocated to the vacant area of the horizontal blanking area H_{BLK} (area in which no effective data is allocated) in the 8-bit word string data DVA showing the image signal information is replaced by 2 word synchronous data DS (8). In this case, if RD of the immediately preceding word data of said replacing area is minus, the word synchronous data to be placed in said area becomes +DS (8) based on the fiber channel standard, and in the case where RD of the immediately preceding word data is plus, the word synchronous data to be replaced in said area becomes –DS (8) based on the fiber channel standard.

With this arrangement, as shown in FIG. **4**, in the data selection unit **18**, of word data (A_0–A_7)–(D_0–D_7) forming the horizontal interval part in the 8-bit word string data DVA, word data (B_0–B_7) and (C_0–C_7) which are inactive data in the horizontal blanking interval will be replaced by the word synchronous data DS (8), and two word synchronous data DS (8) will be consecutively allocated between the word data (A_0–A_7) and word data (D_0–D_7) in the horizontal interval part of the 8-bit word string data DVA. More specifically, two word sync data DS (8) are allocated consecutively between words of the horizontal interval part in the 8-bit word string data DVA, and thus, as shown in FIG. **4**, 8-bit word string data DXA added such as by inserting 2 word synchronous data DS (8) consecutively per the time point th of the front edge part of the timing signal SH will be formed.

Furthermore, in the data selection unit **19**, as shown in FIG. **3**(B), at each horizontal interval of the 8-bit word string data DVB showing the image signal information, 2 words of inactive data allocated to the vacant area of the horizontal blanking area H_{BLK} (area in which no effective data is allocated) will be replaced by 2 auxiliary word data DN (8).

Thus, as shown in FIG. **4**, in the data selection unit **19**, of word data (A_8–A_{15}) - (D_8–D_{15}) forming the horizontal interval part in the 8-bit word string data DVB, each inactive word data (B_8–B_{15}) and (C_8–C_{15}) of the horizontal blanking interval is replaced by the auxiliary word data DN (8) and two auxiliary word data DN (8) will be allocated consecutively between the word data (A_8–A_{15}) and the word data (D_8–D_{15}) in the horizontal interval part of the 8-bit word string data DVB. More precisely, two auxiliary word data DN (8) are allocated consecutively between words of the horizontal interval part in the 8-bit word string data DVB, and as a result, as shown in FIG. **4**, inserting two auxiliary word data DN (8) in succession per the time point th of the front edge part of the timing signal SH, 8-bit word string data DXB will be formed.

8-bit word string data DXA and DXB to be obtained from the data adder unit **15** comprising the data selection units **18** and **19** will be supplied to the 10-bit word string data forming unit **20** (FIG. **2**). The 10-bit word string data forming unit **20** is comprised of a bit conversion unit **21** to which the 8-bit word string data DXA and DXB are supplied as input data and a parallel/serial (P/S) conversion unit **22** to which the output data to be obtained from the bit conversion unit **21** is supplied.

The bit conversion unit **21** is comprise of 8–10 bit conversion units **23** and **24** as shown in FIG. **2**. In the 8–10 bit conversion unit **23**, the 8-bit word string data DXA in which 2 word synchronous data DS (8) are allocated to the part corresponding to the horizontal blanking interval in each horizontal interval part to be obtained from the data selection unit **18** in the data adder unit **15** will be supplied, and the 8-bit word string data DXB in which **2** auxiliary word data DN (8) are allocated to the part corresponding to the horizontal blanking interval in each horizontal interval part to be obtained from the data selection unit **19** in the data adder unit **15** will be supplied into the 8–10 bit conversion unit **24**.

Then, in the 8–10 bit conversion unit **23**, 8–10 bit conversion is given to the 8-bit word string data DXA and the 8-bit word string data DXA is converted to 10-bit word string data DZA. In this case, regarding each of two word synchronous data DS (8) allocated to the part corresponding to the horizontal blanking interval in each horizontal interval part in the 8-bit word string data DXA, firstly, if the RD of the immediately preceding word data of the first word synchronous data DS (8) is minus, it is converted to the word synchronous data +DS (10) that is the word synchronous data DS (10) formed with 10 bits having plus RD, i.e., bit converted to "001111 1010". Moreover, when the RD of the immediately preceding word data is plus, it is converted word synchronous data –DS (10) that is the word synchronous data DS (10) formed with 10 bits having minus RD, i.e., bit converted to "110000 0101". And when the first one is bit converted to the word synchronous data +DS (10) having plus RD, i.e., "001111 1010", the following second one will be bit converted to the word synchronous data –DS (10) that is the word synchronous data DS (10) formed with 10 bits having minus RD, i.e., "1110000 0101". And when the first one is bit converted to the word synchronous data –DS (10) having minus RD, i.e., "110000 0101", the second one is bit converted to the word synchronous data +DS (10) that is the 10-bit word data DS (10) having plus RD, i.e., "001111 1010".

Accordingly, in the 10-bit word string data DZA that is formed in the 8–10 bit conversion unit **23**, as shown in FIG. **5**(A), the 10-bit word synchronous data +DS (10) having plus RD, i.e., "001111 101011", and following this the 10-bit word synchronous data –DS (10) having minus RD, i.e., "110000 0101" are allocated to the part corresponding to the horizontal blanking interval in its each horizontal interval part, or contrary to this, as shown in FIG. **5** (B) the condition

in which the word synchronous data −DS (10), i.e., "110000 0101" is followed by the word synchronous data +DS(10), i.e., "001111 1010" is allocated.

Here, the condition in which +DS (10) shown in FIG. 5(A) is firstly allocated or the condition in which −DS (10) shown in FIG. 5(B) is allocated first will be determined depending on the polarity of RD (minus or plus) of the immediately preceding word data of the word synchronous data.

Furthermore, in the 8–10 bit conversion unit 24, the 8–10 bit conversion is applied to the 8-bit word string data DXB and the 8-bit word string data DXB is converted to 10-bit word string data DZB. In this case, regarding each of 2 auxiliary word data DN (8) inserted to the part corresponding to the horizontal blanking interval in each horizontal interval part in the 8-bit word string data DXB, i.e., "000 00001", as shown in FIG. 6, when CRD of the immediately preceding word data is minus, the first one is bit converted to "011101 0100" that is the neutral word data formed with 10 bits DN (10) (hereinafter referred to as 10-bit neutral auxiliary word data). And when CRD of the immediately preceding word data is plus, it is bit converted to "100010 1011" that is the other neutral auxiliary word data DN (10) formed with 10 bits . Then, when the first one is bit converted to "011101 0100", the second one will be bit converted to "100010 1011" that is 10-bit neutral auxiliary word data DN (10), or when the first one is bit converted to "100010 1011" that is the 10-bit neutral auxiliary word data DN (10), the second one will be bit converted to "011101 0100" that is the 10-bit neutral auxiliary word data DN (10).

Accordingly, regarding the 10-bit word string data DZB formed in the 8–10 bit conversion unit 24, in the part corresponding to the horizontal blanking interval in its each horizontal interval part, the condition in which 10-bit neutral auxiliary word data DN (10) "100010 1011" is followed by the 10-bit neutral auxiliary word data DN (10) "011101 0100", or contrary to this, the 10-bit neutral auxiliary word data DN (10) "011101 0100" is followed by the 10-bit neutral auxiliary word data DN (10) "100010 1011" is allocated. In this case, if both the neutral auxiliary word data "011101 0100" and "100010 1011" are shown as DN (10), as shown in FIG. 5(C), this is the condition in which two neutral auxiliary word data DN (10) are consecutively exist.

10-bit word string data DZA and DZB obtained respectively from the 8–10 bit conversion units 23 and 24 in the bit conversion unit 21 will be supplied to the P/S conversion unit 22. In the P/S conversion unit 22, the P/S conversion that converts 20 bits parallel data formed by adding up 10-bit word string data DZA and 10-bit word string data DZB to serial data is conducted and the composite 10 bits word string data DZ (serial data) will be formed.

In this case, the 10-bit word synchronous data having plus RD +DS (10), i.e., "001111 1010" and the 10-bit word synchronous data having minus RD −DS (10), i.e., "110000 0101", which are allocated to the part corresponding to the horizontal blanking interval in each horizontal interval part of the 10-bit word string data DZA, and the 10-bit neutral auxiliary word data DN(10), "100010 1011" and the 10-bit neutral auxiliary word data DN(10) "011101 0100" which are allocated to the parts corresponding to the horizontal blanking interval in each horizontal interval part of the 10-bit word string data DZB will be processed that, as shown in FIG. 4, the composite 10-bit word string data DZ (serial data), is to be allocated to the part corresponding to the horizontal blanking interval in each horizontal interval part in order that two 10-bit word synchronous data DS (10) and 10-bit neutral auxiliary word data DN (10) range alternately in succession.

Two 10-bit word synchronous data DS(10) and the 10-bit neutral auxiliary word data DN (10) ranging alternately in succession will be placed between word data (A_{10}–A_{19}) in the 10-bit word string data DVB' that can be obtained by giving the 8–10 bit conversion to the 8-bit word string data DVB and word data (D_0–D_9) in the 10-bit word string data DVA' that can be obtained by giving the 8–10 bit conversion to the 8-bit word string data DVA. The processing of assigning two 10-bit word synchronous data DS (10) and the 10-bit neutral auxiliary word data DN (10) alternately between the word data (A_{10}–A_{19}) and the word data (D_0–D_9) in the part corresponding to the horizontal blanking interval in each horizontal interval part of the composite 10-bit word serial data DZ alternately will be conducted as follows:

Firstly, the first one in the 10-bit word synchronous data having plus RD +DS (10) allocated to the part corresponding to the horizontal blanking interval in each horizontal part of 10-bit word string data DZA, i.e., "001111 101011" and the 10-bit word synchronous data having minus RD −DS (10), i.e., "1001111 0101" will be selected. As shown in FIG. 7(A), in the case where the first one is the 10-bit word synchronous data +DS (10) having plus RD and follows the word data (A_{10}–A_{19}) having minus RD, i.e., "001111 1010", then next, the 10-bit neutral auxiliary word data DN (10) inserted to the part corresponding to the horizontal blanking interval in each horizontal part of the 10-bit word string data DZB, i.e., "11100010 1011" or "011101 0100", will be selected. Then, the 10-bit word synchronous data having minus RD −DS (10) inserted to the part corresponding to the horizontal blanking interval in each horizontal interval part of the 10-bit word string data DZA, i.e., "11110000 0101" will be selected, and further the 10-bit neutral auxiliary word data DN (10) inserted to the part corresponding to the horizontal blanking inteval in each horizontal interval part of the 10-bit word string data DZB, i.e., "011101 0100" or "110000 0101" will be selected.

In this case, the 10-bit word synchronous data having plus RD +DS (10), i.e., "001111 1010", the 10-bit neutral auxiliary word data DN (10) "1100010 1011" or "011101 0100", the 10-bit word synchronous data having minus RD −DS (10), i.e., "11110000 0101", and the 10-bit neutral auxiliary word data DN (10) "011101 0100" or "100010 1011" will be placed in succession on the part corresponding to the horizontal blanking interval in each horizontal part of the composite 10-bit word string data DZ that is serial data.

On the other hand, as shown in FIG. 7(B), at the time when the first one selected from the 10-bit word synchronous data having plus RD +DS (10), i.e., "001111 1010" and the 10-bit word synchronous data having minus RD −DS (10), i.e., "110000 0101", is the one that follows the word data (A_{10}–A_{19}) having minus RD and is the 10-bit word synchronous data having minus RD −DS (10), i.e., "110000 0101", the 10-bit neutral auxiliary word data DN (10) inserted to the part corresponding to the horizontal blanking interval in each horizontal interval part of the 10-bit word string data DZB, "011101 0100" or "1100010 1011" will be selected next. Then, the 10-bit word synchronous data having plus RD +DS (10) inserted to the part corresponding to the horizontal blanking interval in each horizontal part of the 10-bit word string data DZA, i.e., "001111 1010" will be selected, and furthermore, 10-bit neutral auxiliary word data DN (10) inserted to the part corresponding to the horizontal blanking interval in each horizontal part of the 10-bit word string data DZB, "100010 1011" or "011101 0100" will be selected.

In this case, the 10-bit word synchronous data having minus RD, i.e., "110000 0101", the 10-bit neutral auxiliary word data DN (10) "01110 0100" or "100010 1011", the 10-bit word synchronous data having plus RD +DS (10), i.e., "001111 1010", and the 10-bit neutral auxiliary word data DS (10) "100010 1011" or "011101 0100" will be placed consecutively on the part corresponding to the horizontal blanking interval in each horizontal interval part of the composite 10-bit string data DZ (serial data).

More specifically, the 10-bit word synchronous data having minus RD -DS(10), i.e., "110000 0101" and the 10-bit synchronous the serial data composite 10-bit word string data DZ to be obtained from the optical receiving unit **31** will be supplied to the serial/parallel (S/P) conversion unit **32**.

At this point, FIG. **9** shows the detailed construction of the receiving end shown in FIG. **8**, and the S/P conversion unit **32** transmits the 10-bit word string data DZ received via said optical receiving unit **31** to the word synchronous data detection unit **36**. The word synchronous data detection unit **36** detects the word synchronous data +DS (10) "001111 1010" assigned at the transmitting end from the 10-bit word string data DZ. In this case, the word synchronous data detection unit **36** is adopted to conduct 20 bits synchronous detection based on the fiber channel standard and it detects "001111 1010" as the 10-bit word synchronous data having the plus RD countering in serial data DZ, and "011101 0100" or "100010 1011" as the 10-bit neutral auxiliary word data DN (10) following said word synchronous data +DS (10).

As shown in FIGS. **6** and **7**, word string data to be assigned is arranged in the order of -DS (10) and +DS (10), or +DS (10) and -DS (10) depending upon plus or minus of the RD of the immediately preceding word data of the area replaced by the word synchronous data. Accordingly, in the serial data DZ which is formed by multiplexing the word synchronous data and neutral auxiliary word data DN (10), +DS (10) and -DS (10) certainly exist having the 10-bit neutral auxiliary word data DN (10) between.

Accordingly, if 20-bit synchronous detection is conducted in the word synchronous data detection unit **36**, 20-bit data formed in combination of word synchronous data +DS (10) and neutral auxiliary data DN (10) can be certainly detected. The word synchronous data detection unit **36** thus detected the word synchronous data +DS (10) cuts out the serial data DZ per 10 bits by the dividing timing signal SD obtained based on the word synchronous data +DS (10), and simultaneously, distributes said cut out 10-bit data between the first channel and the second channel alternately.

The 10-bit word string data DZA put in the first channel and the 10-bit word string data DZB put in the second channel will be supplied to the bit conversion unit **33** (FIG. **9**). The bit conversion unit **33** is comprised of a 10–8 bit conversion unit **34** and a 10–8 bit conversion unit **35** for example. The 10-bit word string data DZA to be obtained from the S/P conversion unit **32** and word clock will be supplied to the 10–8 bit conversion unit **34**, and the 10-bit word string data DZB to be obtained from the S/P conversion unit **32** and the word clock will be supplied to the 10–8-bit conversion unit **25**.

In the 10–8 bits conversion unit **34**, 10–8 bits conversion is applied to the 10-bit word string data DZA, and the 10-bit word string data DZA is converted to the 8-bit word string data DXA. Moreover, in the 10–8 bits conversion unit **35**, 10–8 bits conversion is applied to the 10-bit word string data DZB and 10-bit word string data DZB is converted to the 8 bit word string data DXB.

The 8-bit word string data DXA obtained from the 10–8 bits conversion unit **34** in the bit conversion unit **33** and the 8-bit word string data DXB formed in the 10–8 bits conversion unit **35** of the bit conversion unit **33** are supplied to data reproduction unit **37**. And the word synchronous detection output signal DS obtained from the word synchronous data detection unit **36** is supplied to the synchronizing pulse forming unit **38**. In the synchronous pulse forming unit **38**, horizontal synchronizing pulse signal PS synchronized with the detection output signal SDS obtained when the 10-bit word synchronous data +DS (10) having plus RD, i.e., "1001111 1010", is detected per the part corresponding to the horizontal blanking interval in the horizontal interval part of the word synchronous data detection unit **36** is formed. Then, the horizontal synchronizing pulse signal PS obtained from the synchronizing pulse forming unit **38** will be supplied to the data reproduction unit **37**.

The data reproduction unit **37** is comprised of such as a data separation unit **39** and a data separation unit **40** as shown in FIG. **9**. The 8-bit word string data DXA obtained from the 10–8 bits conversion unit **34** of the bit conversion unit **33** and the horizontal synchronizing pulse signal PS obtained from the synchronizing pulse forming unit **38** will be supplied into the data separation unit **39** and furthermore, the 8-bit word string data DXB obtained from the 10–8 bits conversion unit **35** in the bit conversion unit **33** and the horizontal synchronizing pulse signal PS obtained from the synchronizing pulse forming unit **38** will be supplied into the data separation unit **40**.

In the data separation unit **39**, as well as EAV (end of active video) based on the horizontal synchronizing pulse signal PS is added to the 8-bit word string data DXA in which 2 word synchronous data DS (8) are applied to the part corresponding to the horizontal blanking interval in each horizontal interval part, data separation is provided under the horizontally synchronized condition, 8-bit word string data DVA showing image signal information and 8-bit word synchronous data DS (8) are separated from the 8-bit word string data DXA and these DVA and DS (8) are transmitted to data terminals **42** and **43** respectively.

Furthermore, in the data separation unit **40**, as well as EVA and SAV based on the horizontal synchronizing pulse signal PS are added to the 8-bit word string data DXB in which 2 auxiliary word data DN (8) are applied to the part corresponding to the horizontal blanking interval in each horizontal interval part, data separation is applied under the horizontally synchronized condition, 8-bit word string data DVB showing image signal information and 8-bit auxiliary word data DN (8) are separated from the 8-bit word string data DXB and these are transmitted to data terminals **44** and **45** respectively.

In the example of receiving device shown in FIG. **8** and FIG. **9**, the word synchronous data detection to the 10-bit word string data DZA that is obtained from the composite 10-bit word string data DZ received will be executed by only detecting the 10-bit word synchronous data +DS (10) having plus RD, i.e., "001111 1010" and not detecting the 10-bit word synchronous data -DS (10) having minus RD, i.e., "001111 0101". Even under such condition, since the received composite 10-bit word string data (serial data) DZ is arranged in the order that the 10-bit word synchronous data +DS (10) having plus RD, i.e., "001111 1010" is succeeded by "110000 0101", or the 10-bit word synchronous data -DS (10) having minus RD, i.e., "110000 0101" is succeeded by "001111 1010", and these are replaced having neutral auxiliary word data DN (10) between respectively, word synchronous data detection at each part

corresponding to the horizontal blanking interval in each horizontal interval part of 2 channels of image signal information multiplexed to the composite 10-bit word string data (serial data) DZ can be certainly conducted, and as a result, in 2 channels of 10-bit word string data separated from the composite 10-bit word string data (10) DZ, i.e., DZA and DZB, the word synchronization can be certainly conducted at each horizontal interval.

Since in the receiving device, even though the word synchronous data detection to the 10-bit word string data DZA obtained from the composite 10-bit word string data DZ detects only the 10-bit word synchronous data −DS (10) having minus RD, i.e., "1110000 0101" and not detect the 10-bit word synchronous data +DS (10) having plus RD, i.e., "1001111 1010", the received composite 10-bit word string data DZ is inserted in the order that the 10-bit word synchronous data +DS (10) having plus RD, i.e., "11001111 1010" and the 10-bit word synchronous data −DS (10) having minus RD, i.e., "110000 0101" are so arranged that "001111 10101" is succeeded by "110000 0101" or "110000 0101" is succeeded by "001111 1010" at the part corresponding to the horizontal blanking interval in each horizontal interval part, the word synchronous data detection in every part corresponding to the horizontal blanking interval in each horizontal part of the composite 10-bit word string data (serial data) DZ can be certainly conducted and as a result, it is assumed that the word synchronization has been certainly conducted on 2 channels of 10-bit word string data DZA and DZB separated from the composite 10-bit word string data (serial data) DZ at horizontal intervals.

In said example shown in FIGS. **1**, **2**, and **3**, the composite 10-bit word string data DZ obtained from the 10-bit word string data forming unit **20** is converted to optical signal LZ by the optical transmission unit **25** and to be transmitted through the data transmission path **26** formed by using optical fiber. However, in the data transmission device according to this invention, the composite 10-bit word string data equal to the composite 10-bit word string data DZ may be transmitted directly, such as via the data transmission path formed by a coaxial cable, or via wireless transmission.

Furthermore, the embodiment described above in FIGS. **1**, **2** and **3** has dealt with the case of transmitting 2 channels of image signal information. However, the present invention can be applied tp the case of transmitting one channel or more than three (3) channels, provided that the word synchronous data +DS (10) and −DS (10) and the neutral auxiliary word data DN (10) are arranged on a part of transmission data, and furthermore, the signal to be transmitted is not only limited to image signal, but also the present invention can be applied to the case when transmitting other various data.

INDUSTRIAL APPLICABILITY

The present invention can be utilized in the case where the word synchronization is conducted at horizontal intervals at the receiving end when transmitting image signal.

What is claimed is:

1. A data transmission method, comprising the steps of:

inputting data including video data, EAV and SAV;

bit converting said inputted data to fibre-channel packet data of 10-bit words, said fibre-channel packet data inserts 10-bit word synchronous data having preset codes at a predetermined timing, at least two said 10-bit word synchronous data are inserted in said fibre-channel data, if the immediately preceding word data is data having a plus running disparity, said 10-bit word synchronous data is data having a minus running disparity, and if the immediately preceding word is word data having a minus running disparity, said 10-bit word synchronous data is data having a plus running disparity;

serial data converting said fibre-channel packet data; and

transmitting said serial converted said fibre-channel packet data.

2. The transmission data according to claim **1**, said fibre-channel packet data further inserts neutral word data having a neutral running disparity between said two 10-bit word synchronous data.

3. A data transmission apparatus comprising:

an input means for inputting data including video data, EAV and SAV;

a fibre-channel packet data forming means for forming said data to fibre-channel packet data of 10-bit words, said fibre-channel packet data inserts at least two 10-bit word synchronous data having preset codes at a predetermined timing, if the immediately preceding word data is data having a plus running disparity, said 10-bit word synchronous data is data having a minus running disparity, and if the immediately preceding word data is data having a minus running disparity, said 10-bit word synchronous data is data having a plus running disparity; and

serial data converting means for converting said fibre-channel packet data to serial data and for outputting said serial data.

4. The transmission data apparatus according to claim **3**, wherein said fibre-channel packet data forming means further inserts neutral word data having a neutral running disparity between said two 10-bit word synchronous data.

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